RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

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PREFACE.

THE first Review of the Mineral Production of India, published by the Geological Survey, appeared in Part I of Volume XXXII of the Records. In preparing it, the Director, Sir Thomas Holland, designed the general plan of the work and surveyed the progress made during the preceding six years (1898-1903). The two succeeding Reviews, covering the periods 1904-1908, and 1909-1913, were written by Sir Thomas Holland and Sir Henry Hayden respectively, in each case with the collaboration of myself as junior author. The remaining reviews covering the periods 1914-1918, 1919-1923, and 1924-1928, were prepared by then Directors, Sir Henry Hayden and Sir Edwin Pascoe, assisted by several of the senior officers, some with special knowledge of particular minerals. These Quinquennial Reviews have followed the same general scheme as Sir Thomas Holland's original review, but have been made purposely more descriptive. The reason for this in the earlier reviews was the fact that Ball's Manual on Economic Geology had long been out of print. Mr. LaTouche's Bibliography of Indian Geology and Physical Geography, with its Annotated Index of Minerals of Economic Value, published in 1917, took the place of Ball's Manual, and the descriptive parts of the Quinquennial Review might, therefore, be now thought unnecessary. It is considered, however, that the descriptive matter, so long as it is kept within bounds, not only makes a more connected narrative and ensures a truer interpretation of mere statistics, but provides an opportunity of drawing attention to crucial geological facts pertaining to new discoveries.

An attempt has been made in the present review to reduce the length, but some old matter excluded has been balanced by new matter added. It is the seventh of the series, and has been prepared on the same lines as the last by the collaboration of the available senior officers of the Geological Survey, who have individually revised the sections committed to their charge. The name of the officer responsible for the revision of each section is shown in the Contents and at the head of each article. The general plan has been retained, and in many cases the descriptive parts have also remained much the same as they were when originally written. Recent additions to our information have, of course, been inserted and figures and statistics brought up to date.

L. L. FERMOR.

The 16th July, 1935.

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QUINQUENNIAL REVIEW OF THE MINERAL PRODUCTION OF INDIA FOR THE YEARS 1929 TO 1933. *By the Director and Senior Officers of the Geological Survey of India.*

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I.—INTRODUCTION.

[L. L. FERMOR.]

In the first Review it was explained that, although many valuable mineral products were being worked in different parts of the country, it was impossible to obtain figures relating to some of them sufficiently precise to be of any value for statistical purposes. The most conspicuous of these 'minerals'—classified as such for convenience sake—are the various forms of building material and slate, which are naturally used extensively in every district and would form an excellent index of material progress, if reliance could be placed on the figures returned and if the figures of one period could be regarded as fairly comparable with those of another.

Grouping of the minerals.

In order to obtain some mental impression of progress, we are compelled to exclude from the list of minerals contributing to the statement of total values, those about which we can obtain only partial figures or rough local estimates. The minerals are thus reviewed in two groups, as before, namely:—

Group I.—Those for which approximately trustworthy annual returns are obtainable; and

Group II.—Those regarding which regularly recurring and full particulars cannot be procured.

As the methods of collecting the returns become more precise from year to year and the machinery employed for the purpose becomes more efficient, the minerals included in Group I tend to increase in number; that group now comprises:—

Antimony.	Iron.
Chromite.	Jadeite.
Coal.	Lead.
Copper.	Magnesite.
Diamonds.	Manganese.
Gold.	Mica.
Graphite.	Monazite.
Ilmenite.	Nickel.

Petroleum.
Ruby, Sapphire and Spinel.
Salt.
Saltpetre.
Silver.
Tin.
Tungsten
Zinc.
Zircon.

As the Burma Ruby Mines Ltd. ceased work in 1931, so that reliable statistics of gem production in the Mogok Stone Tract are no longer obtainable, it may prove necessary in the next Quinquennial Review to transfer 'Ruby, Sapphire and Spinel' to Group II.

Units recognised.

Unless otherwise stated, the ton referred to in this review is the English statute ton of 2,240 lbs. Where there are totals likely to be of interest to foreign readers, weights are also expressed in metric tons of 1,000 kilogrammes each (equal to 0·984 statute ton). Returns in *maunds*[1] have been translated into tons, hundredweights and quarters throughout. The output of petroleum has been given in Imperial gallons, and totals are expressed also in metric tons, on the assumption that one metric ton is equivalent to 249 gallons of crude oil of an average specific gravity of 0·885. Values in sterling are calculated throughout at the approximate average rate of exchange for the particular year; this rate of exchange is indicated in each case.

Sources of information.

The data employed in this review have been obtained from various sources. Before the year 1904 the Annual Statistics of Mineral Production were published by the Director-General of Statistics. Since then the figures of mineral production for India have been published annually in the Records of the Geological Survey of India. Returns of mineral production are now sent by Local Governments, Political Agents and in a few cases by Indian Durbars, direct to the Director of the Geological Survey, except in the case of mines under the Mines Act, when the figures are forwarded direct by mine-managers to the Chief Inspector of Mines, who forwards a summary to the Geological Survey. Information regarding exports and imports has been derived from the publications issued by the Director-General of Commercial Intelligence and Statistics, whose co-operation in other ways has also been of great assistance. Additional information has been obtained from the following sources:—

(1) Annual Returns of the Chief Inspector of Mines in India, and the Chief Inspector of Mines for Mysore;

[1] One *maund*=82·3 lbs.

(2) Annual Administration Reports of the various Local Governments and Local Administrations in India;

(3) Annual Administration Reports of the Railway Board;

(4) Returns issued by the various Geological Surveys and Statistics relating to Mines and Quarries, published by the English Home Office.

(5) Reports by the Imperial Institute, London.

We are also indebted to the Managing Agents and General Managers of several Mining Companies for much information supplied direct.

II.—SUMMARY OF PROGRESS.

[L. L. Fermor.]

Total values.

Table 1 summarises the output and value of the principal minerals produced during the five years under review. The total values have the obvious defect of being the addition of unlike denominations. This applies much more markedly to the quinquennium 1919-1923 during which the exchange varied between the wide limits of 1*s.* $2\frac{15}{16}$*d.* and 2*s.* $10\frac{1}{2}$*d.* per rupee. Between 1924 and 1928, the exchange varied from 1*s.* $4\frac{1}{2}$*d.* to 1*s.* $6\frac{9}{32}$*d.* per rupee; whilst in the period now under review, the rate of exchange has varied between the narrower limits of 1*s.* $5\frac{3}{4}$*d.* and 1*s.* $6\frac{5}{32}$*d.* per rupee. This variation in exchange, small as it is compared with that of the previous ten years, combined with a variation in the actual intrinsic value of the minerals and the enhanced effect caused by the lack of synchronism between the time of purchase and the time of payment, detracts considerably from the precision of statistics. Furthermore, export values, being the only returns obtainable in some cases, are ranged with spot values, while the latter necessarily vary with the position of the mine, representing not the *values* but the *prices* obtainable. In the case of coal, for instance, the so-called value of a ton of good coal in Bengal is less than half that of the inferior material raised in Baluchistan; in the case of salt, the values given are the prices charged, and are less than the duty, which is the principal value of the salt to Government. Certain valuable mineral products, such as building stones, are omitted altogether for want of any but very approximate estimates, as are all the other minerals in Group II.

The values returned for minerals exported are also necessarily lower than they would be if those minerals were consumed in the country, and it is consequently unfair to compare this table of values with corresponding returns for countries in which metallurgical industries flourish on a larger scale than in India. Manganese-ore is a conspicuous example of a product the value of which, to the Indian producer, is reduced by the heavy cost of transport. The country is thus not only so much poorer by the loss of the metal exported in the ore, but is paid in return considerably less than its market value.

TABLE 1.—*Output and value of Minerals for which reliable returns of production are available for the years 1929-33.*

Mineral.		1929. (£1 = Rs. 13·4)	1930. (£1 = Rs. 13·5)	1931. (£1 = Rs. 13·5)	1932. (£1 = Rs. 13·3)	1933. (£1 = Rs. 13·3)	*Average.*
Coal . . .	£ tons	6,668,591 23,418,734	6,861,134 23,803,048	6,125,804 21,716,435	5,119,684 20,153,387	4,599,830 19,789,163	*5,875,009* *21,776,153*
Petroleum . .	£ gals.	4,800,448 306,148,093	3,888,727 311,030,108	4,380,389 305,018,751	3,818,875 308,606,031	4,707,959 306,009,022	*4,319,280* *307,362,401*
Gold . . .	£ oz.	1,542,109 363,869	1,384,090 329,232	1,540,885 330,489	1,906,123 320,682	2,078,201 336,108	*1,690,282* *337,876*
Lead and lead-ore .	£ tons	1,845,641 79,757	1,346,051 78,340	939,906 73,280	820,109 70,560	851,320 70,560	*1,160,605* *74,499*
Salt . . .	£ tons	854,692 1,734,660	775,927 1,571,206	1,024,117 1,874,054	916,386 1,656,843	878,645 1,763,561	*889,953* *1,720,064*
Manganese-ore (*a*) .	£ tons	1,523,803 964,489	1,117,796 773,026	565,078 417,957	198,525 301,252	212,264 376,354	*723,511* *566,616*
Silver . . .	£ oz.	802,734 7,298,327	571,005 7,072,050	387,351 5,923,005	471,557 6,026,737	497,213 6,080,241	*545,972* *6,480,072*
Mica (*b*) . .	£ cwts.	784,092 116,075	562,054 82,909	307,316 52,966	251,800 47,021	307,671 57,717	*442,587* *71,338*
Copper-ore (*f*) and Copper-matte.	£ tons	506,639 84,822	533,162 136,933	408,891 157,687	350,223 176,071	407,821 194,457	*441,347* *149,994*
Tin-ore . . .	£ tons	436,895 3,694	311,523 3,944	238,225 3,899	311,526 4,157	484,034 4,504	*356,440* *4,040*
Iron-ore . .	£ tons	484,947 2,430,136	360,928 1,849,624	308,055 1,621,881	294,720 1,760,500	187,813 1,228,625	*327,293* *1,778,753*
Zinc concentrates .	£ tons	408,958 58,435	190,615 57,620	127,669 51,455	113,481 44,484	231,800 61,432	*214,505* *54,685*
Tungsten-ore . .	£ tons	117,293 1,397	151,941 2,779	75,64[illegible] 2,60[illegible]	62,535 2,390	98,885 2,604	*101,260* *2,355*
Saltpetre (*b*) . .	£ cwts.	71,720 91,708	53,445 76,538	73,414 123,116	92,272 165,782	117,136 189,566	*81,597* *129,342*
Nickel-speiss . .	£ tons	47,670 3,065	53,790 3,150	49,921 2,911	77,269 3,580	77,333 3,350	*61,197* *3,211*
Ilmenite . .	£ tons	28,602 23,670	32,99[illegible] 28,776	41,091 36,166	58,134 50,053	61,087 52,980	*44,741* *38,329*
Chromite . .	£ tons	62,818 49,565	64,256 50,684	23,335 19,913	20,727 17,865	16,785 15,526	*37,584* *30,711*
Jadeite (*c*) . .	£ cwts.	36,280 2,137	16,187 1,475	26,094 2,500	28,359 2,654	13,513 1,799	*24,087* *2,113*
Antimonial lead and antimony-ore.	£ tons	25,231 1,277	26,300 1,703	14,781 1,505	6,627 642	17,907 1,485	*18,187* *1,322*
Ruby, Sapphire and Spinel.	£ carats	24,758 44,650	9,715 30,090	3,175 (*d*)	.. ..	(*e*) 44 (*e*) 1,103	*7,538* *15,169*
Magnesite . .	£ tons	9,865 23,497	6,277 16,523	2,026 5,333	5,470 13,864	7,344 15,206	*6,196* *14,884*
Zircon . . .	£ tons	10,805 1,473	4,991 640	7,972 855	3,805 491	3,375 675	*6,190* *827*
Diamonds . .	£ carats	9,485 1,628	5,373 1,321	2,569 639	5,428 1,254	4,789 2,342	*5,529* *1,437*
Monazite . .	£ tons	1,800 180	140 14	890 90	6,147 654	1,592 139	*2,114* *215*
TOTAL VALUE .	£	**21,105,966**	**18,328,420**	**16,675,503**	**14,939,782**	**15,865,351**	***17,383,004***

(*a*) Export value of quantities actually exported.
(*b*) Export figures.
(*c*) Exports by sea during official years.
(*d*) Not available.
(*e*) Excludes 1,464,158 carats of sapphires with corundum valued at £6,917.
(*f*) Ore milled.

In the Annual Reviews of Mineral Production the minerals of Group II are included in the table of total values. These totals fell from a maximum of £22,328,686 in 1929 to £15,612,235 in 1932, with a recovery to £16,618,069 in 1933, the average for the period being £18,409,843, a figure £1,026,839 higher than the average of value of Group I minerals as shown in Table 1 of the present review. Of this difference £911,126 is due to buildings materials alone.

Comparison with the previous periods.

The imperfections of Table 1 of this review are those confessedly inseparable from all such estimates of mineral production. Nevertheless, it is of interest to compare the total values in Table 1 of this review with the values as given in the corresponding tables in previous reviews. This comparison is made in Table 2 showing the averages of each period since this review was instituted, the

TABLE 2.—*Value of production in India of minerals in Group I for the period 18.8-1903 and the six following quinquennial periods.*

Period.	Number of minerals valued.	Average annual value of total production.	Average annual values of petroleum production.	Average annual values of total production without petroleum.
		£	£	£
1898-1903 . . .	14*	4,253,706	185,810	4,067,896
1904-1908 . . .	16*	6,716,325	592,887	6,123,438
1909-1913 . . .	20*	8,393,222	928,072	7,465,150
1914-1918 . .	21*	11,822,743	1,073,604	10,749,139
1919-1923 . . .	20	24,615,727	7,036,298	17,579,429
1924-1928 . . .	24	23,875,578	6,268,229	17,607,349
1929-1933 . . .	24	17,383,004	4,319,280	13,063,724

* Includes one Group II mineral, amber.

first review being for the six-year period 1898 to 1903. The steady increase from quinquennium to quinquennium up to the war period is a measure of the steady growth of industries in India. The great increase in values for the first post-war period 1919-1923 is partly

a measure of the great increase in prices of all commodities, but partly due to a revised method of valuing the production of petroleum in Burma adopted by the Government of Burma in 1920.

Mineral.	1913.	1920.	1933.
	Tons.	Tons.	Tons.
Coal	16,208,009	17,962,214	19,789,163
Salt	1,299,281	1,630,123	1,763,561
Iron-ore	370,845	558,005	1,228,625
Manganese-ore(*a*)	804,796	805,839	376,354
Copper-ore and copper-matte	3,810	28,167	194,457
Lead and lead-ore	5,939	23,909	70,560
Zinc concentrates	..	..	61,432
Ilmenite	..	..	52,980
Chromite	5,676	26,801	15,526
Magnesite	14,086	14,346	15,206
Saltpetre(*a*)	14,846	22,133	9,478
Tin and tin-ore	7,062	2,282	4,504
Nickel-speiss	..	..	3,350
Mica(*a*)	2,695	3,826	2,886
Tungsten-ore	1,688	2,346	2,604
Antimonial lead and antimony-ore	..	..	1,485
Zircon	..	..	675
Monazite	1,235	1,641	139
Graphite	..	100	..
Jadeite(*a*)	180	255	90
	Ozs.	Ozs.	Ozs.
Gold	595,761	499,068	336,108
Silver	125,209	2,906,397	6,080,241
	Carats.	Carats.	Carats.
Diamonds	116	85	2,342
Ruby, sapphire, spinel	278,706	155,604	1,103
	Gallons.	Gallons.	Gallons.
Petroleum	277,555,235	293,116,834	306,009,022
Value with Petroleum	£9,971,141	£29,289,858	£15,805.351
Value without Petroleum	£8,936,555	£21,272,038	£11,157,392

(*a*) Export figures.

Prior to this year, the Government of Burma valued the petroleum production at Rs. 2-8-0 per barrel of 42 gallons, but in 1920 the figure of Rs. 0-4-6 per gallon was substituted as more correct. This rate has been applied retrospectively to the 1919 production, increasing this from £1,834,308 as first published to £8,340,894—an increase of over £6½ millions. As a result of this there is a statistical 'fault' between 1918 and 1919 of the order of £6½ millions with 1919 on the 'upthrow' side, in consequence of which the figures for the last three periods cannot be compared with those of the first four periods without allowing for this 'fault'. The 'throw' of the 'fault' has decreased markedly from 1927 onwards, but is still of the order of £3 millions compared with the first four periods. Consequently it has been thought suitable to show in the last column of Table 2 the average annual values for each period of the Indian mineral production without petroleum. From this it will be seen that there was a great increase in the value of the Indian mineral production for the two quinquennia 1919-1923 and 1924-1928, the peak years being 1920 and 1924 with values of £21,272,038 and £20,124,665 respectively (excluding petroleum). Since 1924, the value has fallen rapidly to £11,120,907 in 1932 at the nadir of depression, rising slightly to £11,157,392 in 1933 (excluding petroleum). Even at the nadir of depression, however, the value of the Indian production (excluding petroleum) was some 24 per cent. greater than in the last pre-war year, 1913 (£8,936,555). The extent to which the increase is due to increased prices and increased mineral production respectively may perhaps be judged from the accompanying statement of production in 1913, 1920 and 1933 (*see* page 13).

Fluctuations in output and value.

During the quinquennial period under review, the output of coal has fallen steadily since 1930, and this fall has unfortunately been accompanied by an equally steady and noticeable drop in value. The output of petroleum has been steady, but the value has fluctuated about 11 per cent. on either side of the mean. The secular decline in the output of gold continued during 1929 and 1930, but was arrested in 1931 as a result of Britain's departure from the gold standard. Both the quantity and the value of the manganese-ore production show a catastrophic fall. The quantity and value of iron-ore produced also shows a heavy fall. There was a moderate general decrease in the production of lead, zinc and silver, accompanied by a very heavy fall in values, with a marked recovery in

1933 in the case of zinc. Copper and copper-matte showed a large general increase in quantity accompanied by a large fall of values until 1932. The output of nickel-speiss was steady but there was a considerable increase in value in the last two years. There was a steady increase in the output of tin helped by the tin restriction scheme in which India does not participate; for the same reason there was a large recovery in values from the low figures of 1931. The output of tungsten-ore was steady at a substantially higher figure than in the previous period. The quantity and value of both chromite and mica fell heavily. Ilmenite showed a marked general increase in quantity and value. The decline in the output and value of saltpetre continued until 1930, since when there has been a marked recovery. Salt production was moderately steady. The quantity and value of magnesite fell heavily until 1931, since when there has been a partial recovery. The average production of both zircon and monazite was close to that for the previous period, with the value of the zircon somewhat higher and that of the monazite somewhat less. Ruby, sapphire and spinel fell to zero in 1931, but there was a small production in 1933. The output of diamonds was substantially higher both in quantity and value than in the previous period.

Prices of minerals and mineral products.

The extent to which these fluctuations in recorded values are due to variations in market prices influencing both the quantity of output of each mineral and the monetary return secured for the quantity actually produced can be judged partly by studying Table 3 in which is shown the average sterling prices of some of the principal metals and mineral products during the quinquennium under review. With the one exception of gold, which shows a great increase in price from 1931 onwards due to Britain's departure from the gold standard, all these metals, ores and petroleum products show falls in price, often of great magnitude. In some cases there has already been a recovery from the minimum due to a variety of causes, of which a restriction scheme in the case of tin is the most potent, the rises in some other cases being due to a slight recovery from the maximum of depression. Of these products, gold was at its minimum in 1930; spelter, tin, silver and chromite in 1931; ferro-manganese in 1931 to 1933; copper, pig-iron, wolfram and petrol in 1932; steel rails and manganese-ore in 1932 and 1933; pig-lead and kerosene in 1933.

TABLE 3.—*Average prices in the United Kingdom of Principal Metals and Ores, and of Petrol and Kerosene during the years 1929-1933.*

—	—	1929.	1930.	1931.	1932.	1933.
Metals*—						
Copper, standard, per ton	£	75·48	54·67	38·39	31·73	32·30
Lead, pig, soft foreign, per ton	£	23·24	18·08	13·03	12·04	11·80
Spelter, ordinary, per ton	£	24·88	16·75	12·44	13·69	15·74
Tin, standard, per ton	£	203·94	141·95	118·45	135·94	194·59
Pig-iron, Cleveland No. 3, per ton	£	3·52	3·35	2·93	2·92	3·12
Steel rails, per ton	£	8·50	8·50	8·38	8·37	8·37
Ferro-manganese, per ton	£	13·53	11·91	11·25	11·25	11·25
Gold, fine, per ounce	*Sh.*	84·941	85·064	92·492	118·037	124·802
Silver, standard, per ounce	*d.*	24·614	17·462	14·665	17·834	18·148
Ores*—						
Chromite, per ton	£	(*a*)4·296	(*a*)4 158	(*a*)4·055	(*a*)4·698	(*a*)4·625
Manganese-ore, first grade, per unit	*d.*	14·0	13·1	11·7	9·5	9·5
Wolfram, per unit	*Sh.*	29·28	22·75	13·59	12·31	15·42
Oils†—						
Petrol, per gallon	*d.*	12·62	12·46	8·76	8 37	9·10
Kerosene,‡ per gallon	*d.*	9·75	9·86	8·66	8·50	7·38

* Compiled mainly from the *Mining Magazine*, the *Mining Journal* and the *Iron and Coal Trades Review*.
† Compiled from the *Petroleum Times*. Price excludes import duty.
‡ *Snowflake* brand.
(*a*) Price of 48—57 per cent. Cr_2O_3.

India as a producer of metals.

The important extent to which India has become a producer of metals of recent years is seen from Table 1. In addition to the output of gold in the Kolar goldfield, of iron and steel by the Tata Iron & Steel Company at Jamshedpur, and of pig-iron by the Bengal Iron Company at Kulti and the Indian Iron & Steel Company at Hirapur, we have the operations of the Burma Corporation of Bawdwin with the large output of lead, silver, zinc concentrates, copper-matte, nickel-speiss and antimonial lead. In addition, copper smelting with production of refined copper and yellow metal (brass sheet) by the Indian Copper Corporation, has become a permanent industry in Singhbhum.

Mineral Production of the United Kingdom.

Table 4 shows the values of the more important mineral products of the United Kingdom during the year 1933. The enormous preponderance of the coal industry in the United Kingdom is remarkable, although much less than it was some years previously. Iron-ore, the next most important mineral product in the world, takes the fifth place. It is of interest that the value of building materials and fluxes (nearly £13 millions) is not far short of that of the total Indian production for the same year as shown in Table 1.

TABLE 4.—*Values (a) during 1933 of the twelve leading Mineral Products in the United Kingdom.*

	£
Coal	134,646,091
Clay (including china and fire clays) and shale	2,886,172
Limestone and dolomite	2,691,540
Igneous rocks	2,681,282
Iron-ore	1,607,868
Gravel and sand	1,514,938
Slate	1,491,028
Sandstone (other than ganister and silica rocks)	1,239,222
Salt	1,019,372
Gypsum	479,091
Chalk	444,503
Oil shale	400,963

(*a*) Value at mine or quarry.

Imports of minerals and mineral products.

In this summary also it will be interesting to note the value recorded for imported minerals and for products obtained directly from minerals during the period under review. These figures, exclusive of the values of cutlery and hardware, machinery and millwork, railway plant and rolling stock, earthenware and porcelain, glass and glassware, jewellery and plate of gold and silver, paints and colours, and alizarine and aniline dyes, are shown in Table 5. The chief features, brought out by a comparison of this table with the corresponding table in the previous Review, are a general decrease in the quantities imported accompanied by a general fall in values.

One complete exception is quicksilver, which showed a small increase in quantity and a substantial increase in value, the year of greatest world depression being, strangely enough, marked by abnormally high imports of quicksilver both in quantity and value. The other important complete exception is inorganic chemicals, which showed a substantial increase in values compared with the average

TABLE 5.—*Amount and value of Imports of minerals and products obtained directly from minerals for the years 1929 to 1933 (including Government stores).*

—		1929.	1930.	1931.	1932.	1933.	*Average.*
Salt . . .	Rs.	1,26,41,245	1,21,67,509	80,42,798	82,32,507	51,17,923	*92,40,396*
	tons	607,277	688,513	528,594	552,741	366,818	*548,788*
Metals—							
Brass . .	Rs.	2,34,51,089	1,76,46,310	1,37,61,164	1,80,37,909	1,32,49,176	*1,72,29,310*
	cwts.	457,943	377,092	365,253	555,490	442,441	*439,644*
Copper . .	Rs.	1,16,57,985	1,04,30,918	1,00,21,796	1,22,88,613	78,71,140	*1,04,54,090*
	cwts.	192,034	188,936	232,620	337,374	243,663	*238,925*
German silver .	Rs.	15,63,983	15,40,213	9,48,680	10,43,080	13,28,648	*12,84,921*
	cwts.	18,352	19,154	13,548	14,949	17,512	*16,703*
Iron . .	Rs.	15,06,400	12,99,908	5,95,229	6,54,627	7,94,209	*9,70,093*
	tons	11,027	8,646	4,680	4,721	6,418	*7,098*
Iron or steel .	Rs.	16,12,32,372	11,31,85,835	6,25,97,840	4,65,90,079	4,52,56,982	*8,57,72,792*
	tons	824,529	607,795	328,290	239,000	238,550	*439,635*
Steel . .	Rs.	3,16,17,559	1,56,93,801	1,05,08,531	81,19,873	76,73,776	*1,47,22,708*
	tons	270,839	136,014	109,803	91,330	73,573	*132,312*
Lead . .	Rs.	9,78,561	7,86,014	6,30,881	3,83,363	5,14,971	*6,58,758*
	cwts.	44,966	38,220	37,383	24,816	29,506	*34,978*
Quicksilver .	Rs.	8,62,311	7,94,402	7,44,579	11,88,103	6,94,237	*8,56,726*
	lbs.	204,036	186,642	185,667	332,749	239,090	*229,817*
Tin . .	Rs.	88,55,449	66,53,634	39,55,317	49,54,972	57,16,012	*60,27,077*
	cwts.	60,990	61,084	45,830	51,581	44.481	*52,703*
Zinc . .	Rs.	37,72,069	32,54,052	22,46,613	37,56,385	34,51,678	*32,96,159*
	cwts.	182,687	198,340	199,611	334,739	283,013	*239,678*
Unenumerated	Rs.	15,45,042	15,35,269	9,09,190	8,87,095	9,31,832	*11,61,685*
	cwts.	33,300	36,333	23,214	24,387	26,867	*28,820*
Total value of metals.	**Rs.**	**24,70,43,720**	**17,28,20,356**	**10,69,19,820**	**9,79,04,999**	**8,74,82,701**	***14,24,34,310***
Inorganic chemicals.	Rs.	2,75,13,302	2,76,05,649	2,62,50,913	2,83,21,516	2,62,18,850	*2,71,83,846*
Mineral oil . .	Rs.	10,71,46,140	11,19,05,615	8,85,87,820	7,76,91,254	6,00,97,021	*8,90,85,570*
	gals.	252,457,775	253,599,297	211,625,214	206,123,120	189,041,559	*222,569,393*
Paraffin . .	Rs.	3,18,670	3,85,787	1,95,226	61,513	54,222	*2,03,084*
	cwts.	19,220	32,900	16,940	3,740	3,740	*15,108*
Coal, coke and patent fuel.	Rs.	42,05,706	41,38,820	17,83,789	10,10,903	12,59,737	*24,97,791*
	tons	218,759	217,080	88,035	47,675	67,532	*127,816*
Precious stones and pearls, unset.	Rs.	1,14,06,837	64,78,746	54,52,405	69,78,277	79,77,676	*76,58,788*
Stone and marble	Rs.	4,90,767	5,17,282	4,63,160	4,87,522	5,64,721	*5,04,680*
	tons	6,106	5,206	4,992	5,745	8,966	*6,203*
Other building materials.	Rs.	1,35,86,002	1,20,45,785	99,65,084	72,51,381	68,33,531	*99,36,357*
Total value .	Rs.	**42,44,42,389**	**34,80,65,499**	**24,76,70,015**	**22,79,30,872**	**19,56,06,382**	***28,87,44,831***
	£	**31,674,805**	**25,782,629**	**18,345,927**	**17,138,336**	**14,707,247**	***21,529,789***
		(£1 = Rs. 13·4)	**(£1 = Rs. 13·5)**	**(£1 = Rs. 13·5)**	**(£1 = Rs. 13·3)**	**(£1 = Rs. 13·3).**	

of the previous period, and this increase in values doubtless represents a substantial increase in quantities also, though these are not recorded. In addition, zinc, mineral oil, paraffin, stone and marble, all showed decreases in value, accompanied by a large increase in quantity in the case of zinc, and small increases in the other cases. The increase in imports of zinc in 1932 and 1933 is probably partly due to the manufacture of yellow metal sheet by the Indian Copper Corporation.

This almost general fall in quantities and values is, of course, largely an expression of the reduction of world industry and trade due to the recent depression, which reached its acme in 1932, and from which India, Britain and some other countries are only just recovering. The most important fall is that of 'iron or steel' from an average of nearly 800,000 tons valued at 17·17 crores of rupees in 1924-1928 to some 440,000 tons valued at 8·58 crores in 1929-1933, the imports for 1933 being only 238,000 tons valued at 4·52 crores. The imports of 'iron' and 'steel' showed comparable large falls. 'Coal, coke and patent fuel' also showed a very large percentage decrease. The decrease in this last case must be partly attributed to the operations of the Indian Coal Grading Board, as a result of which Indian coal is now more carefully graded than in the past. The marked decrease in the case of copper and the small decrease in the case of brass must be correlated partly with the manufacture of copper and brass in India.

Table 6 is also of much interest. During the previous period the value of the imports of a more finished nature shown in this table was remarkably steady and averaged some £27,000,000 annually. The figures for the present review are not strictly comparable as no statistics have been obtained of the imports of railway plant and rolling stock which in the period 1924-1928 had an average value of some £6,000,000. Under the stress of the economic depression the imports shown in Table 6 have fallen rapidly from £25 millions in 1929 to £14¼ millions in 1932, recovering slightly to over £15 millions in 1933, with an average for the whole period of nearly £18½ millions.

For comparison with imports of minerals and mineral products into India, it is interesting to give also a table showing the amount and value of exports of minerals and products obtained directly from minerals in India, for the years 1929-1933. This is done in Table 7.

Exports of minerals and ineral products.

TABLE 6.—*Value of Imports of products of a more finished nature manufactured almost entirely from minerals or mineral products for the years 1929 to 1933 (including Government stores).*

—	1929.	1930.	1931.	1932.	1933.	*Average.*
	Rs.	Rs.	Rs.	Rs.	Rs.	*Rs.*
Machinery and millwork	21,58,23,118	18,86,88,956	13,42,30,983	11,02,75,964	12,87,40,082	*15,55,51,821*
Cutlery and hardware	5,69,79,480	4,47,11,481	3,37,36,689	3,06,41,675	3,19,63,976	*3,96,06,660*
Glass and glassware	2,55,12,759	1,82,72,428	1,42,46,865	1,37,46,723	1,28,08,849	*1,69,17,525*
Alizarine and aniline dye	1,81,85,305	2,19,04,885	2,33,90,278	2,38,35,552	1,95,00,092	*2,13,63,222*
Paints and colours	1,14,96,756	93,27,323	71,15,696	68,98,567	71,56,800	*83,99,028*
Earthenware and porcelain	74,48,685	55,15,567	42,16,390	45,29,442	45,47,890	*52,51,595*
Total value Rs.	**33,54,46,103**	**28,84,20,610**	**21,69,36,901**	**18,99,27,923**	**20,47,17,689**	***24,70,89,851***
Total value sterling	**£25,033,291**	**£21,364,492**	**£16,069,400**	**£14,280,295**	**£15,392,307**	***£18,427,957***
	(£1=Rs. 13·4)	(£1=Rs. 13·5)	(£1=Rs. 13·5)	(£1=Rs. 13·3)	(£1=Rs. 13·3)	

TABLE 7.—*Amount and value of Exports of minerals and products obtained directly from minerals for the years 1929 to 1933.*

——		1929.	1930.	1931.	1932.	1933.	*Average.*
Salt	tons	2.058	12	7	14	14	*421*
	Rs.	40.550	3,081	1,720	2,494	2,379	*10,045*
Saltpetre	Cwts.	91,708	76,538	123,117	165,782	189,567	*129,342*
	Rs.	9,61,051	7,21,501	9,91,087	12,27,321	15,57,919	*10,91,776*
Metals and ores—							
Borax	Cwts.	2 339	972	968	935	723	*1,187*
	Rs.	45,117	18,498	17.923	19,122	12,596	*22,651*
Chromite	Tons	32.402	29,978	13.248	25,638	17.232	*23,679*
Copper	,,	10,509	16,724	14.213	11,251	11.887	*12,917*
	Rs.	43,80,668	67,87,090	32,18,189	25,35,314	26,79,846	*39,20,221*
Ferro-manganese	Tons	4,198	..	..	..	..	*840*
	Rs.	96,500	..	..	..	..	*19,300*
Ferruginous manganese-ore	Tons	22,560	5,750	6,700	..	..	*7.002*
	Rs.	1,35,360	36,000	48,500	..	..	*43,972*
Iron pig	Tons	548,881	502.629	318.994	248,396	372,015	*398,183*
	Rs.	2,50.86,155	2,06,99,058	1,12,03.467	86,65,502	91.07,292	*1,49,52,295*
Lead pig	Tons	72 328	72.813	68,515	61,361	65,045	*68,012*
	Rs.	2,42,06.000	2.21.58,912	1,81,05,629	1,60,03.952	1,49.04,564	*1,90,75,811*
Manganese-ore	Tons	964.489	773,026	417,957	301,252	376,354	*566,616*
	Rs.	2,04.20,116	1,50,90.246	76,28,553	26,40,383	28,23,111	*97,20,482*
Mica	Cwts.	116,075	82,909	52,966	47,021	57.717	*71.338*
	Rs.	1,05,06.834	75,87,731	41,48,768	33,48,943	40,92.033	*59,36,862*
Monazite	Tons	312	..	..	..	..	*62*
	Rs.	55.446	..	..	..	..	*11,089*
Tin and tungsten ores	Tons	4,984	6,042	6,844	5,817	6.819	*6,101*
	Rs.	89,17.587	91,91,371	89.17.733	77,68,892	1.05.98,127	*90,78,742*
Zinc	Tons	67.408	64,800	54.818	49.950	64,050	*60,205*
Unenumerated	,,	12.366	13,628	9.084	7.773	12,248	*11,020*
	Rs.	22.18.893	18,42,368	12,69,526	11,22,865	14,36,973	*15,78,125*
TOTAL	Rs.	**9,70,70,277**	**8,41,35,856**	**5,55,51,095**	**4,33,34,788**	**4,72,14,840**	***6,54.61.371***
Coal, coke and patent fuel	Tons	726.610	461,188	441,249	519,483	426,176	*514,941*
	Rs.	75.57,332	51,87,917	49 32,725	51.76.864	41,10,471	*53,93,062*
Jadestone	Cwts.	2 530	1,517	1,826	3.345	2.111	*2.266*
	Rs.	6,25.836	1,75.786	3,40.012	4,46,686	1,27,703	*3,43,204*
Mineral oil	Gals.	113,038	77,355	68.935	114.102	73,575	*89,401*
	Rs.	1.47,930	95,467	69.540	1.27,827	88,970	*1,05,951*
Paraffin wax	Cwts.	1.280,120	1,223,880	1,032.040	942.160	1,035.260	*1,102,692*
	Rs.	3,10.02.432	2,98.31.182	2,33.37,917	2.10,37,801	2,22,93.389	*2,55,00,544*
Precious stones and pearls unset	Rs.	60,349	15,183	15,339	4,078	630	*19,116*
Stone and marble	Tons	2.712	2,718	4,491	3,085	11,433	*4,888*
	Rs.	1,94,092	1,16,585	1,08.640	79,341	3,43,786	1,68,489
TOTAL	Rs.	**3,95,87,971**	**3,54,22,120**	**2,88,04,193**	**2,68,72,597**	**2,69,64,949**	***3,15,30,366***
GRAND TOTAL	Rs.	**13,66,58,248**	**11,95,57,976**	**8,43,55,288**	**7,02,07,385**	**7,41,79.789**	***9,69,91,737***

From this it will be seen that the average annual value of exports during the quinquennium has been Rs. 9,69,91,737 compared with Rs. 28,87,44,831 for the imports during the same period. The most important exports in order of value have been paraffin wax, pig-lead, pig-iron, manganese-ore, tin and tungsten-ores, mica, coal, coke and patent fuel, copper, saltpetre. Mineral oil has ceased to be an export of importance.

Consumption.

From the figures of production, imports and exports it is, of course, possible to deduce the quantities of minerals and mineral products retained annually for consumption in India. In a recent paper[1] tables are given for the years 1913, 1917, 1920, and 1926 to 1931, of (1) mineral production, (2) metal production, (3) imports and (4) exports. Further data are given of mineral reserves for certain minerals as they stood in 1931, and also a table of smelting and refining facilities as on the 31st July, 1932. In addition, a table (Table V) is given for the year 1931 showing the production, retained imports, exports of domestic production, and deduced from these data, the minerals, ores and metals available for consumption in India. Similar tables of consumption are given in the annual reviews of mineral production for 1932 and 1933. The data from these three tables showing the minerals and metals available for consumption in India after allowing for the effects of imports and exports are shown in Table 8 for the three years 1931 to 1933. In later Reviews it will be possible to give similar figures for the complete quinquennium.

Labour figures.

It is interesting also to collect into one table such reliable labour statistics as are available for the different minerals, in order to show the relative magnitude of the various mineral industries of India during the quinquennium. These figures are shown in Table 9, from which it will be seen that the average number of persons employed daily during the quinquennium in all mines for which reliable returns of labour statistics are available was 340,341, of which 173,179 persons were employed in the coal industry. The most important sources of employment otherwise were the industries for producing salt, petroleum, gold, manganese-ore, mica and iron-ore.

Excluding labour statistics relating to the salt industry it is observed that the average total number of persons employed daily

[1] L. L. Fermor, 'Tables of Production, Imports, Exports and Consumption of Minerals and Metals in India', *Rec. Geol. Surv., Ind.*, LXVI, pp. 472-534, (1933).

TABLE 8.—*Ores, minerals, and metals available for Consumption in India in 1931 to 1933.*

Ores, minerals and metals.	Kinds and grades.	Unit.	1931.	1932.	1933.
Aluminium . .	Metal . . .	Cwts.	44	238	138
Arsenic . . .	Metal and oxides .	Cwts.	2,107	2,649	2,020
Barytes . . .	....	Tons	10,184	5,130	8,565
Bismuth . . .	Mostly native . .	Lbs.	42	27	80
Borates . . .	Borax (including boracic acid.).	Cwts.	18,742	29,197	20,815
Brass . . .	....	Tons	21,467	32,759	27,940
Clays . . .	Other than China clay	,,	137,603	117,398	378,590
Chromite . . .	....	,,	6,670	..	..
Coal, coke and bye-products.	Coal . . .	,,	21,355,449	19,679,023	19,427,697
	Coal-tar and pitch .	,,	50,544	49,169	52,061
	Sulphate of ammonia	,,	24,128	41,811	41,447
Copper . . .	Metal (unwrought) .	..	4,342	4,560	5,396
Diamonds . . .	....	Carats	639	1,254	2,342
Felspar . . .	....	Tons	..	473	677
Ferro-manganese .	....	,,	14,366	866	7,725
Ferro-alloys . .	....	,,	1,502	495	1,432
Fuller's earth . .	....	,,	7,743	7,886	7,663
Graphite . . .	....	Tons	508	208	532
Gypsum . . .	....	,,	53,632	54,741	38,142
Iron	Pig	,,	740,625	663,674	687,670
	Steel . . .	,,	546,577	521,410	548,990
Lead	Pig . . .	,,	4,965	9,331	5,619
Manganese-ore . .	....	,,	119,887	..	..
Ochre . . .	....	,,	4,951	6,237	11,630
Petroleum . . .	Petrol including benzene and dangerous spirit.	Gals.	77,364,924	74,947,257	71,544,473
	Kerosene . . .	,,	220,547,049	223,987,534	197,133,278
	Fuel oil . . .	,,	118,907,681	118,687,036	122,668,49
	Batching and lubricating oils.	,,	28,445,021	25,063,169	29,457,298

TABLE 8.—*Ores, minerals, and metals available for Consumption in India in 1931 to 1933*—contd.

Ores, minerals and metals.	Kinds and grades.	Unit.	1931.	1932.	1933.
Phosphates . .	....	Tons	8,163	5,302	3,429
Potash minerals and chemicals.	Saltpetre . .	Cwts.	13,600	14,000	9,000
	Chemicals and manures	,,	142,721	157,185	168,832
Quicksilver . .	...	Lbs.	185,517	332,601	239,090
Salt	....	Tons	2,116,604	1,918,292	1,822,236
Silver . . .	....	Fine ounces.	41,265,279	..	..
Steatite . . .	....	Tons	5,135	6,512	17,048
Sulphate of ammonia .	....	,,	24,078	41,811	41,447
Sulphur . . .	...	,,	15,728	16,192	20,212
Tin	Ore	,,	1,523	1,737	1,559
	Metal (unwrought) .	,,	2,082	2,429	2,041
Zinc	Metal (unwrought) .	,,	8,694	15,306	12,610
	Metal (wrought) .	,,	1,878*	1,417	1,515

* 1930-31.

was 279,508 as compared with 313,789 during the previous quinquennium,—a decrease of about 11 per cent. In regard to salt, the figures apparently show a rise from 20,653 daily during 1924 to 1928 to 60,833 during the present quinquennium. It has, however, been discovered that this anomalous increase is due to a miscalculation in the figures reported from Madras during the previous quinquennium, the revised average for that period being 54,645. Including this revised figure, the total number of persons employed in mineral industries for which reliable returns are available shows a decrease of about 8 per cent. as compared with the quinquennium 1924 to 1928.

Mineral concessions granted.

The number of mineral concessions granted annually provides some guide to the prosperity of the mining industry. During the previous period the number of mineral concessions granted annually averaged 719, falling from 859 in 1925 to 497 in 1928. During the period now under review the number of concessions granted annually averaged only 391, falling from 457 in 1929 to 327 in 1932, the year

TABLE 9.—*Average number of persons employed daily in the production of minerals from mines in India for which reliable returns of labour statistics are available.*

—	1929.	1930.	1931.	1932.	1933.	*Average.*
Chromite	1,745	2,143	1,168	1,835	1,577	*1,694*
Coal	179,607	184,370	173,175	165,567	163,173	*173,179*
Copper-ore	463	1,089	1,806	1,853	2,050	*1,452*
Diamonds	1,972	1,354	894	1,223	2,163	*1,521*
Gold	18,551	17,365	18,447	18,892	20,401	*18,731*
Iron-ore	16,617	12,634	14,605	12,215	9,593	*13,133*
Lead-ore	6,057	6,275	3,761	3,173	3,409	*4,535*
Magnesite	1,533	1,006	373	1,021	1,048	*996*
Manganese-ore	31,971	21,093	14,639	5,736	4,545	*15,597*
Mica	16,582	18,111	14,950	12,006	12,559	*14,842*
Monazite, zircon and ilmenite	421	660	853	1,464	1,654	*1,010*
Petroleum	25,931	24,976	26,267	20,710	21,398	*23,856*
Ruby, sapphire and spinel	394	876	696	..	50	*403*
Salt (*a*)	59,598	59,886	61,625	60,341	62,713	*60,833*
Tin and tungsten ores	8,767	9,800	6,667	7,430	10,131	*8,559*
TOTAL	**370,209**	**361,638**	**339,926**	**313,466**	**316,464**	***340,341***

(*a*) Revised figures for the previous quinquennium are as follows:—
40,173 in 1924, 50,629 in 1925, 50,638 in 1926, 59,742 in 1927, and 62,994 in 1928, giving an average of 54,645, (*see* page 24).

of greatest general depression, and recovering to 406 in 1933. The number of quarry leases, prospecting licenses and mining leases granted during this period are shown in Table 10.

TABLE 10.—*Number of Mineral Concessions granted during the years 1929 to 1933.*

Year.	Quarry leases.	Prospecting licenses.	Mining leases.	Total mineral concessions granted.
1929	(a) 17	338	102	457
1930	16	334	64	414
1931	(a) 17	270	64	351
1932	26	249	52	327
1933	24	325	57	406

(a) Including one exploring license.

Summary of the Minerals of Group I.

Antimony.

At intervals since 1915, there has been a small spasmodic output of stibnite from the Amherst district, Burma, the last recorded output being for 1930. Since 1924, however, antimonial lead has been regularly produced from the Bawdwin mine of the Northern Shan States in Burma to the extent of some 1,020 tons a year in the quinquennium 1924-1928, and 1,306 tons a year in the quinquennium under review.

Chromite.

Chromite being a munition of war, its production during the war period rose from an annual average of 4,671 tons to nearly 23,000 tons; during the following quinquennium 1919-1923 it again rose from the latter figure to 35,000 tons, the rise being due principally to the vigorous mining in Baluchistan, which doubled its output. During the five years 1924-1928 there was a 12·3 per cent. decrease in average output from Baluchistan; this was, however, more than balanced by an increased production from Mysore, and the average annual output was nearly 44,000 tons. During the last three years of the period now under review, there has been a great fall in production from both Baluchistan and Mysore, slightly neutralised

by a great increase in the small output of Singhbhum, so that the total output for 1933 was only some 15,500 tons, and the average for the whole period was only some 30,700 tons.

Coal.

During the period 1924 to 1928 the annual production of coal showed a rising tendency with an output of 22½ million tons in 1928, the average for the period being 21½ million tons. The rise continued until 1930 with an output of over 23,800,000 tons, followed by a marked decline to nearly 19,000,000 tons in 1933, the average for the period being some 21¾ million tons. From these data and figure 1 it will be seen that the Indian coal industry after an almost continuous rise during the 14 years 1905 to 1919 (22½ million tons) of an average of one million tons annually, shows, during the succeeding 14 years, no increase at all, but an actual decline as measured by the figures for 1933. It is this failure of demand to expand as anticipated by the industry that is the root cause of the present position of potential overproduction in the Indian coal industry and the present unremunerative prices taken as a whole. During the war, there was a marked rise in raising costs, and the pit's mouth value rose from Rs. 3-9-0 to a then maximum figure of Rs. 4-6-0 in 1918. This figure was altogether eclipsed by that for 1922, which reached Rs. 7-11-0 per ton. In 1923 it fell to Rs. 7-7-0 which was still more than double the pre-war rate. From then onwards there was a rapid and continuous fall to Rs. 3-12-0 in 1928. During the first three years of the present quinquennium the pit's mouth value remained steady at Rs. 3-12-4 to Rs. 3-10-0, but during 1932 and 1933 a further serious fall to Rs. 2-15-0 has occurred. Although the average for the period was Rs. 3-7-0, against an average of Rs. 3-4-6 for the pre-war quinquennium 1909-1913, the present rate, on account of greater costs of working due to more difficult conditions of mining and other causes, is no longer remunerative for a large number of producers.

Throughout the period, India still held her position as the largest coal-producer of any of the British dependencies. She was again completely outdistanced by Japan, whose output in 1932 was about 28 million tons against India's 20 millions. The Gondwana fields produced some 98 per cent. of the Indian output, and the Raniganj and Jharia fields respectively 29·6 and 44·0 per cent. The Bokaro field contributed on an average 7·9 per cent. of India's total output; the output from this field is at present

restricted, but ultimately Bokaro is likely to prove one of the great Indian fields. The Pench Valley coalfield, aided by its favourable position with reference to Western India, showed a rapidly increasing production, which by 1933 had risen to 4·9 per cent. of India's total output.

FIG. 1.—*Production of Coal from 1905 to 1933.*

Figure 2 shows the great variations in exports and imports during and since the war. The abnormal relation of imports to exports that characterised the years 1921 to 1925 disappeared in 1926 and from

this year onwards exports have borne to imports the normal pre-war relation with the difference that the imports are now less than at any time before the war recorded in these reviews. The average exports during the quinquennial period under review amounted to 515,000 tons against 448,500 tons in the previous period, whilst the imports averaged only 128,000 tons against 319,000 in the previous period. In spite of this great decrease in imports, both Japan and South Africa must still be regarded as formidable rivals in Indian Ocean ports.

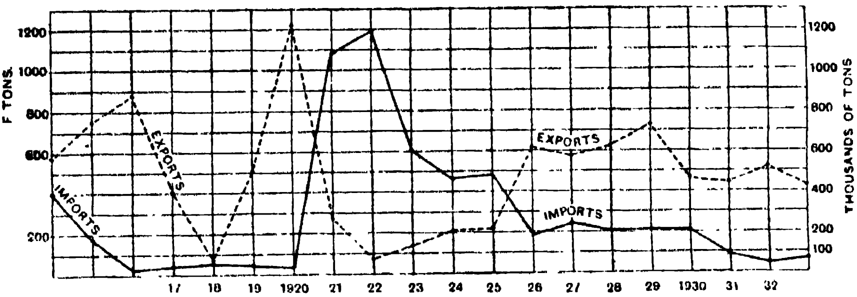

FIG. 2.—*Exports and imports of Coal for the past 20 years.*

The employment of by-product ovens in coke-making has extended considerably and the amount of hard coke manufactured during the period averaged 1,400,000 tons annually, the major portion of this coke being consumed by the iron and steel companies. The by-products recovered are tar and ammonia, sulphate of ammonia being manufactured with acid made locally from imported sulphur. The amount of coal or coke used for domestic purposes in such a densely populated country as India is, however, astonishingly small, being barely 2 million tons of coal and soft coke annually. A greater demand would encourage the exploitation of large untouched reserves of second quality coal and would defeat the reprehensible practice of burning a valuable manure such as cowdung for cooking purposes. To encourage the manufacture of soft coke, the Indian Soft Coke Cess Act, No. VIII of 1929, was accordingly passed with effect from the 1st October, providing for the levy of a cess of two annas per ton upon all soft coke despatched by rail from collieries in Bengal, Bihar and Orissa, the proceeds of the cess to be used for promoting the sale and improving the methods of manufacture of soft coke. It is difficult from the

figures of production of soft coke to detect any evidence that this Act has produced any of the beneficial effects anticipated.[1] For the output of soft coke in Bengal, Bihar and Orissa has fallen from 757,000 tons in 1929 to 724,000 tons in 1931, recovering to 824,000 tons in 1933, the latter showing a smaller increase over the production for 1929 than the normal rate of growth of manufacture prior to 1929 (*see* Table 35).

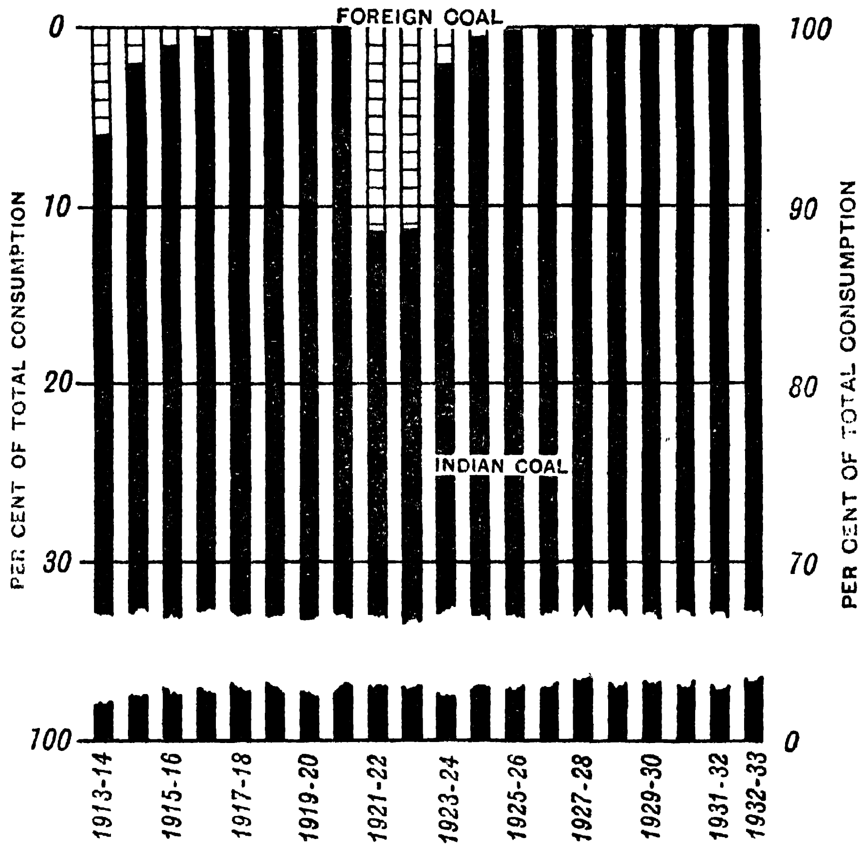

FIG. 3.—*The relative consumption of Foreign and Indian coal on Indian Railways.*

The coal industry in India has been passing through a period of unprecedented difficulty and depression of recent years due to the failure of demand to expand in accordance with development of new collieries and fields, with consequent over-production, low

[1] However, propaganda work has caused a considerable increase of arrivals of wagons of soft coke at selected centres, mainly in Northern India.

prices and deleterious methods of extraction. Proposals for compulsory restriction of output with the object of raising prices have been considered but not adopted: and unless some measures of conservation be introduced, which would of themselves induce restriction of output, there is likely to be much preventible loss of coal due to the methods of extraction being adjusted to low prices.

Copper.

Copper began to figure regularly in our mineral returns during the quinquennium 1914-1918 due to the operations of the Cape Copper Company at the Rakha Mines. Smelting operations were begun in 1918 and some 30 tons of blister copper produced. During the period 1919-1923 the average annual output of copper-ore by the Cape Copper Company rose to 26,159 tons, with a total production of 3,550 tons of metal. This company went into liquidation in 1923. In 1924 a new company, the Indian Copper Corporation, continued the successful operations of the Cordoba Copper Company, with the result that in the quinquennium under review an average annual output of 137,088 tons of ore, 3,584 tons of refined copper, and 3,187 tons of yellow metal sheet was produced. The Bawdwin mine of Upper Burma now yields a regular supply of copper-matte containing about 41 per cent. of copper, the average production of this matte per year during the quinquennium under review having been nearly 13,000 tons.

Diamonds.

The average annual output of diamonds rose from 224 carats in the preceding quinquennium to 1,437 carats in the period under report.

Gold.

The Indian output of gold has fallen steadily from some 616,700 ozs. in 1915 to some 329,200 ozs. in 1930 due primarily to the increasing difficulties of working at great depths and to the more easily won ore having been extracted. With Britain's departure from the gold standard,

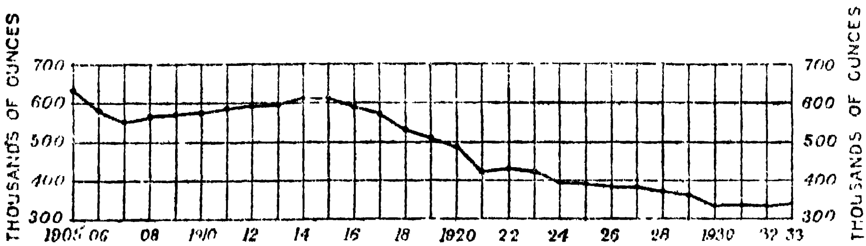

FIG. 4.—*Production of Gold since 1905.*

however, and the resultant increased sterling price of gold, making it feasible to work lower grade ore, the output has risen slightly to 336,100 ozs. by 1933, and the average for the period is 337,876 ozs. against 386,944 ozs. in the previous quinquennium, and 459,875 ozs. in the quinquennium 1919-1923.

Graphite.

Owing to the difficulty of obtaining graphite from extra-Indian sources, there had been a slight revival of indigenous mining during the war period, but it did not persist. The output of graphite amounted to 127 tons in 1919, 100 tons in 1920 and 25 tons in 1921. But for a small output of 20 tons from Mysore, the industry would have died out in 1922. There was no production in 1923 nor during the five years which followed. In the present period 39 tons were produced in Ajmer-Merwara in 1929 and 6·5 and 5 tons in 1931 and 1932 respectively from the Kistna district, Madras. No attempt has been made to reopen the Travancore mines.

Ilmenite.

Ilmenite, produced from the beach sands of Travancore, where it occurs in admixture with monazite and zircon, has become of recent years one of India's important minerals. It was transferred to Group 1 of these Reviews in the previous period 1924-1928 when the output rose rapidly from 641 tons in 1924 to 25,307 tons in 1928, India becoming by 1927 the largest producer of ilmenite in the world. This figure has continued during the present quinquennium, the output rising to 52,980 tons in 1933, with an average for the period of over 38,000 tons. It is used in the manufacture of white paints and to a lesser extent in the manufacture of alloys and of the carbide.

Iron.

In the period under review, the Indian iron and steel industry showed a falling off in output of pig-iron and an increase in output of steel. For whereas the output of pig-iron fell from 1,391,551 tons in 1929 to 913,314 tons in 1932, with a recovery to 1,057,837 tons in 1933, and an average of 1,119,266 tons annually, the output of steel rose from 410,923 tons in 1929 to 505,429 tons in 1933. The Bengal Iron Company's output of pig-iron fell from 196,090 tons in 1929 to 103,929 tons in 1930, after which the blast furnaces were closed as a result of an agreement with the Indian Iron and Steel Company. Nevertheless the production of castings continued, the average annual output being 39,793 tons against 53,698 tons in the previous period. The output of the Tata Iron and Steel Company

rose from an annual average of some 569,500 tons of pig-iron and some 319,000 tons of steel during the previous quinquennium to some 742,000 tons of pig-iron and some 443,000 tons of steel in the quinquennium under consideration. The Indian Iron and Steel Company, which commenced smelting operations at the end of 1922, produced an annual average of 286,000 tons of pig-iron during the quinquennium 1924-1928, rising slightly to 299,000 tons in the period now under consideration. The average annual output of the Mysore Iron Works remained practically unchanged at 17,500 tons. All the producing companies showed minima of production in the year of maximum depression, 1932, this applying to pig-iron, castings, steel, and ferro-manganese. The United Steel Corporation of Asia, Limited was formed by Messrs. Bird and Company who have been producing iron-ore since 1927. The Steel Industry (Protection) Act—No. XIV of 1924—authorised, to companies employing Indians, bounties upon rails and fish-plates wholly manufactured in British India from material wholly or mainly produced from Indian iron-ore and complying with specifications approved by the Railway Board, and upon iron or steel railway wagons a substantial portion of the component parts of which had been manufactured in British India. This Act was repealed by Act No. III of 1927 and the payment of bounties consequently ceased on the 31st March, 1927; the industry is, however, protected to a certain extent by varying tariffs on different classes of imported steel. The Tata Iron and Steel Company claims now (1935) to sell steel rails and galvanized sheets at equal to or below pre-war prices.

Jadeite.

There has been a marked decline in the recorded exports of jadeite during the past two quinquennial periods as compared with the preceding three similar periods. The industry, which is a primitive one, is carried on in the backward territory in the neighbourhood of the Hukong, Upper Burma until recently unadministered.

Lead and Silver.

The Bawdwin mine of the Burma Corporation, Limited, is now one of the great lead-silver-zinc mines of the world, the ore being treated at Namtu. The output of lead extracted from the ore rose steadily from 19,000 tons in 1919 to over 77,000 tons in 1928, and the annual production during 1924-1928 averaged 58,523 tons *plus* 1,020 tons of antimonial lead. During the period now under review the annual production, under the stress of the depression and its much lower

prices for metals, fell from nearly 80,000 tons in 1929 to some 70,000 tons in 1933, the fall being due to deliberate restriction on account of low prices; the quinquennial average was 74,293 tons *plus* 1,306 tons of antimonial lead. The output of silver, which averaged nearly 5¾ million ozs. per year during the previous quinquennial period, averaged nearly 6½ million ozs. during the period under review. Copper-matte and nickel-speiss are also produced from this mine.

Magnesite.

The average annual output of magnesite, which had increased by 77 per cent. during the post-war quinquennium, further increased to some 26,000 tons during the five years 1924-1928, but fell to 14,884 tons during the period 1929-1933, with a minimum of 5,333 tons in 1931. The production was derived mainly from the deposits in Salem, Madras, with a small contribution from Mysore.

Manganese.

With respect to manganese, India in 1907 overtook Russia, hitherto the greatest producer of that mineral, and assumed the first place amongst the world's suppliers of manganese-ore (*see* Plate 6). This lead was lost during the years 1912-1915, but the war reinstated India, so far as the high-grade ore was concerned, in her former supremacy, in spite of increased competition from Brazil due to the same cause. Events since the war did not lead to any change in the relative position of these three leading producers until 1929, when India fell to the second position, and 1933, when during the depression the output of the Gold Coast happened to be somewhat greater. The Gold Coast had already risen to third place at the expense of Brazil as long ago as 1924. The record for the three previous quinquennial periods in India was that of a relatively stable industry which had found its level in the world and had taken advantage of expanding markets. Competition and falling prices have, however, since affected disastrously the prosperity that the manganese industry had enjoyed up to the year 1927. From 1924 the annual production rose from some 803,006 to 1,129,353 tons in 1927, the latter being the highest year's production yet recorded. In 1928 the production dropped to about 978,500 tons, and during the present period the output fell from 994,279 tons in 1929 to 212,604 tons in 1932, with the resultant almost complete cessation of work in the Central Provinces. There was a trivial recovery to 218,307 tons in 1933.

The cause of this catastrophic fall was, of course, primarily the world-wide economic depression, with the drastic curtailment of the iron and steel industry throughout the world (from 97·2 million tons of pig-iron and 118·3 million tons of steel in 1929 to 38·9 million tons of pig-iron and 49·7 million tons of steel in 1932); but the fall was accentuated by the fact that Russia continued to produce and export but slightly reduced quantities of manganese-ore, in spite of the prevalent low prices. As before the war, the bulk of the ore came from the Chiaturi region of Georgia, but Nikopol is a substantial contributor.

The price of first-grade ore, *c.i.f.* United Kingdom ports, fell during the previous quinquennial period from 22·9*d.* per unit in 1924 to 17·0*d.* in 1928. This fall continued during the present period to 9·5*d.* in 1933, *i.e.*, nearly to the pre-war minimum. It was thought by some that when the operations of the Harriman group of American financiers ceased in 1928, the Russian industry would relapse to its earlier position with benefit to the Indian producer. This has not, however, proved to be the case, as the Russian practice has been to sell manganese-ore at whatever it will fetch, and this practice, with the residual benefits of the organisation introduced by the Americans, gives Russia the key to the manganese situation. Another disturbing factor is the discovery of large deposits of high-grade manganese-ore at Postmasburg in the northern part of Cape Province of South Africa, which may ultimately prove a formidable rival to Indian manganese-ore. Brazil is hampered by inadequate transport facilities The Gold Coast, which has outstripped Brazil, is another competitor that India has to consider.

During the five years 1929 to 1933 the proportions contributed by Russia with Georgia, India, the Gold Coast, and Brazil, in the order named, were 43·1 per cent., 22·5 per cent., 11·3 per cent. and 5·1 per cent. respectively, of the world's output, which averaged 2,477,783 statute tons annually. In the previous five years they had been 24·5 per cent., 35·2 per cent., 12·2 per cent., and 9·8 per cent. respectively out of a total output of 2,625,600 tons annually. The United States produced as much as 305,869 tons in 1918, a figure, promoted by war conditions, that will probably never again be approached unless the stimulating conditions are repeated. The United States average output for 1929-1933 amounted to 40,598 tons per annum.

The average annual value of the ore produced in India during the years 1909-1913 was £822,876. This increased to £1,052,403 for the period 1914-1918, and again to £1,995,341 during 1919-1923, the maximum value being £3,525,842 in 1920. During the period 1924-1928 the average annual value of the Indian production

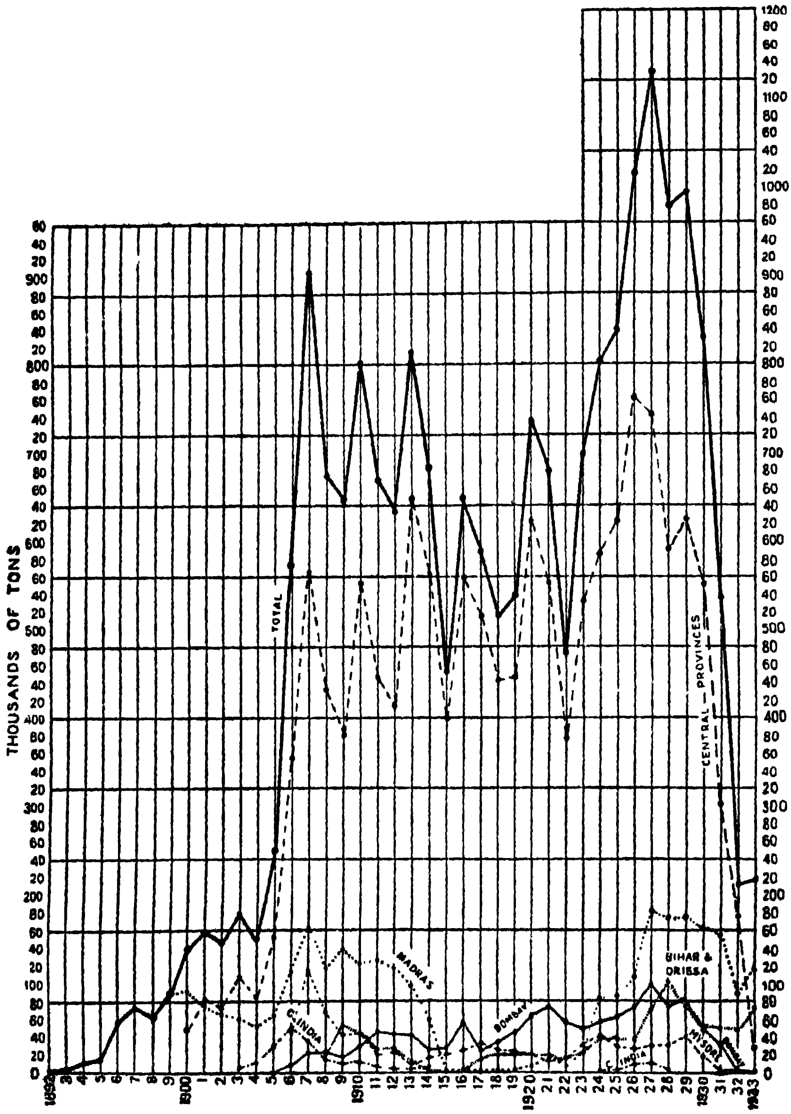

Fig. 5.—*Production of Manganese-ore since 1892.*

amounted to £2,018,835, whilst in the period 1929-1933 the average annual value fell catastrophically to £723,511 *f.o.b.* Indian ports. Taking the average values for the period, manganese-ore has fallen from third to sixth position amongst the minerals produced in India, being exceeded by coal, petroleum, gold, lead and salt. In 1933, however, manganese-ore fell to eleventh position in order of values.

From figure 5 it is seen that by far the larger proportion of the fall of the last few years has occurred in the Central Provinces, whilst Bombay and Mysore have also suffered severely. As a result of this fall Madras became the leading producer in 1933, mainly as a result of the increased production from Sandur State: whilst Bihar and Orissa occupied the second position.

Mica.

India is still the greatest mica-producing country in the world; the fields of Hazaribagh and Nellore produce a large proportion of the world's supply of sheet mica, the United States and Canada being next in importance. Of the total value of the mica produced by these three leading countries, India accounts for some 87 per cent. In addition the output of the Union of South Africa is becoming important. The production of fine splittings by hand is an art which is performed to perfection in India. In fact, when the demand for mica splittings is brisk, a certain amount of mica is actually imported into India for conversion into fine splittings and subsequent export. India also holds a monopoly in the production of shellac, and has it in her power to hold a predominant position in the manufacture of micanite, an artificial commodity made out of the smallest and thinnest films of mica cemented together with shellac dissolved in spirit. Figure 6 shows the fluctuations in the total weight and total value of the mica exported during the past twenty years.

Monazite.

The average annual production of monazite in Travancore during the period under review, namely 215 tons, was almost exactly the same as during the previous five-year period, 214 tons. This is, however, but a small fraction of the production during the years 1914 to 1921 (ranging from 1,107 to 2,117 tons), and the industry has been kept alive of recent years by the sister-industry of ilmenite.

Nickel.

A regular production of nickel-speiss from the Bawdwin mine of Upper Burma was initiated in 1927 and has become a regular feature of the mineral output from this area. The production during the period under

review averaged 3,211 tons valued at £61,197. The speiss produced in 1933 averaged 29 per cent. of silver, 11 per cent. of copper, and 26·6 ozs. of silver to the ton. The speiss contains from 3 to 4 per cent. of cobalt, and is shipped to Hamburg for further treatment.

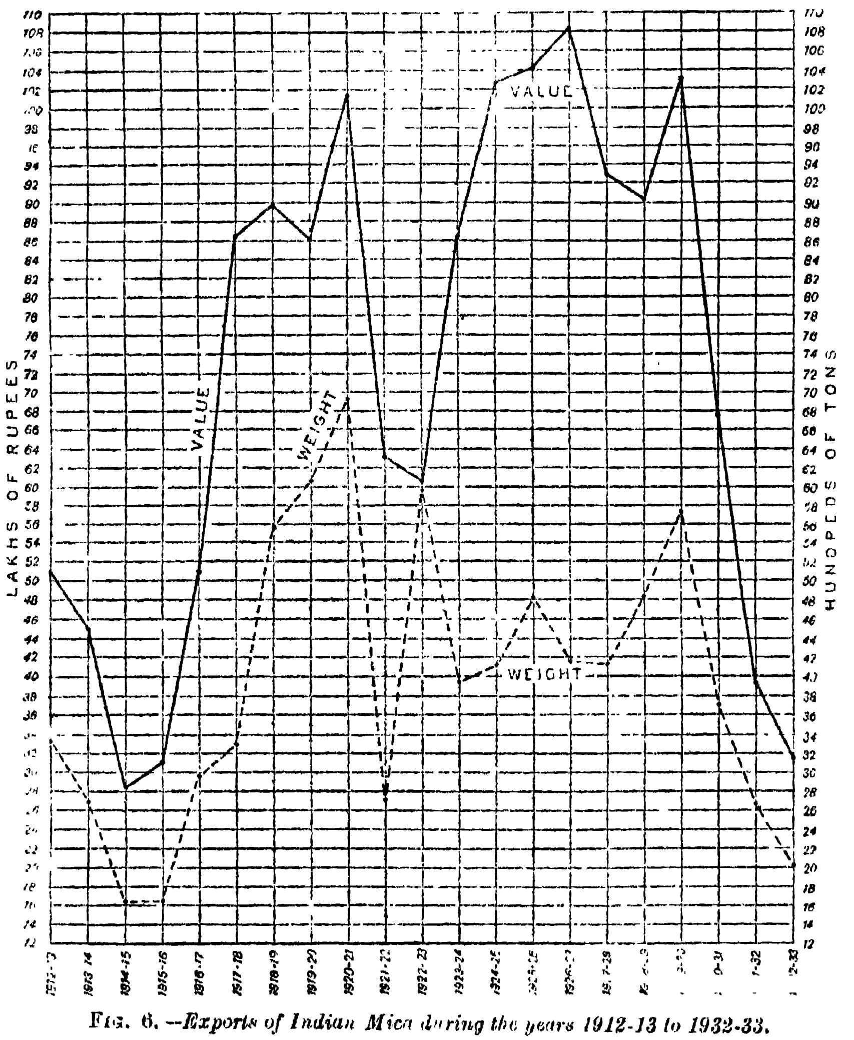

FIG. 6.—*Exports of Indian Mica during the years 1912-13 to 1932-33.*

Petroleum.

The average annual value of petroleum produced has fallen heavily in conformity with the general depression from £6,268,229 for the period of the preceding review to £4,319,280 for the present period. On the

other hand the quantity of the average annual production rose from 290,321,036 gallons in 1924-1928 to 307,362,401 gallons in

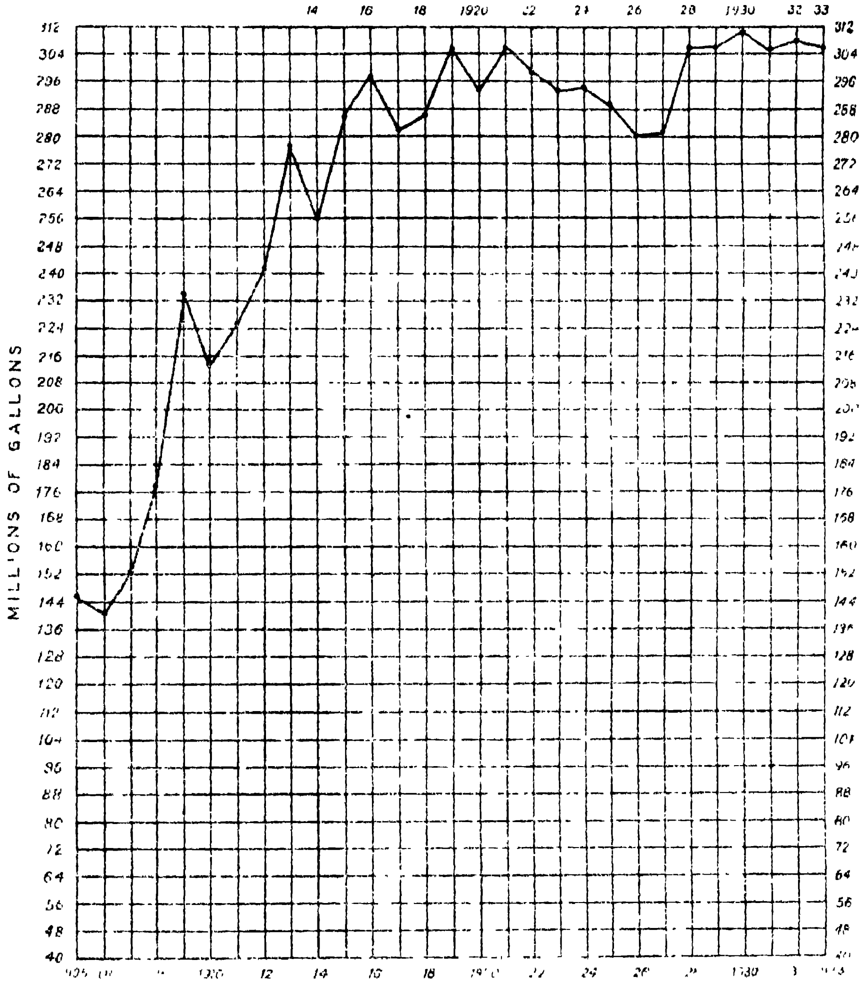

FIG. 7.—*Production of Petroleum since 1906.*

1929-1933, this quinquennial average being higher than any previous annual figure, the maximum output being in 1930 with 311,030,108 gallons. The exports of paraffin wax rose from an annual average of 39,780[1] tons in the previous quinquennium to 55,135 tons in the period under review.

[1] These figures are erroneously given as cwts. in Table 5 of the preceding Review.

The Burma Ruby Mines Limited, which had gone into liquidation in 1925, ceased work during 1931, and the recorded output fell to *nil* in 1932, and the annual average for the quinquennium 1929-1933 was only 15,169 carats valued at £7,538 against 87,135 carats valued at £26,228 during the previous period. There was, however, an output of sapphires and corundum from Kashmir in 1933, valued at £6,917, as a result of an attempt to reopen these deposits, which was resumed in 1934.

Ruby, Sapphire and Spinel.

That the gem industry in the Mogok Stone Tract is being carried on by the hereditary gem miners with undiminished activity is shown by the fact that license fees collected from the indigenous industry have risen from an annual average of Rs. 1,20,490 during the quinquennial period 1924-1928 to Rs. 1,68,971 during the period under review.

Salt.

The amount of salt produced annually during the period 1929-1933 has amounted on an average to 1,720,064 tons, which shows an increase of 183,132 tons over the figure for the previous quinquennium. The annual imports decreased from 580,943 tons in 1924-1928 to 548,783 tons in 1929-1933. Although there has been an increase in the total of Indian production (without Aden) *plus* imports from abroad from 1,924,530 tons annually in the period 1924-1928 to 2,001,052 tons annually during 1929-1933, yet the consumption per head has fallen from 13·5 lbs. per annum for the former period to about 12·5 lbs. per annum for the present period, this apparent fall being largely explained by the increased population recorded in the 1931 census.

Saltpetre.

Owing to the withdrawal of restrictions on the manufacture of saline substances in India, complete production figures for saltpetre subsequent to 1924 are no longer available. There was, however, an annual average production of 8,073 tons of refined saltpetre in Northern India during 1929-1930 to 1933-1934. The exports for the period, however, amounted only to an average of 6,467 tons annually, chiefly to Ceylon, the United Kingdom and Mauritius.

Tin.

In spite of the heavy fall in the average price of tin from an average of £263 in the period 1924-1928 to £159 in the period under review, the average annual output of tin-ore increased from 2,802 tons in the earlier period

to 4,040 tons in the present period, that for 1933, namely 4,504 tons, being the maximum yet recorded. This increase was due to the fact that developments that had been in progress for some years at Mawchi in Karenni at last came to fruition and that developments in Burma were not hampered by the Tin Restriction Scheme, in which Burma has not participated. With the lower average value of tin during the period the large increase in quantity of production was accompanied by only a trival increase in average annual value, namely from £352,846 in 1924-1928 to £356,440 in 1929-1933.

Tungsten.

The large quantities of high-speed tool-steel required throughout the world in consequence of the war, led to a greatly increased demand for tungsten and its raw materials, wolfram and scheelite. Vigorous measures were taken to increase production in Burma; by the year 1917 the output had been more than doubled and amounted to 4,542 tons. The value rose in even greater proportion from £175,150 in 1914 to £726,681 in 1918. These figures, however, were artificial; the price per unit was fixed by the British Government at a figure considerably above the previous market rate and all wolfram was taken over at that price. This, although highly profitable to the producer, did not represent the true market value of the material, the price offered in the American market being nearly double the control rate. After the war the wolfram market suffered an expected collapse, and the output of Burma dwindled to an annual average of only 955 tons for the period 1924-1928, the output for 1928 being only 622 tons. The dominating country in the wolfram market since the war has been China with outputs varying from 10,200 tons in 1918 to 2,100 tons in 1932, rising to 5,500 tons in 1933. During the period under review Burma made a large recovery, partly in consonance and because of the expanding production of tin-ore, to an average output of 2,355 tons, and a peak production of 2,779 tons in 1930, the period being the best as regards quantity since the war.

Zinc.

The production of zinc-concentrates at Bawdwin showed a sudden increase in 1926 so that the average annual production for 1924-1928 was 41,340 tons. During the period under review there was a steady fall from the peak production of 1928 (64,122 tons) to 44,484 tons in 1932, the year of greatest depression, with a sharp recovery in 1933, so that

the average annual output for the period under review was 54,685 tons. On account of the great fall in the price of spelter the value of the average annual production fell from £376,345 in 1924-1928 to £214,505 in 1929-1933.

Zircon.

Zircon, recovered as one of the constituents of the beach sands of Travancore, together with ilmenite and monazite, showed a small increase from an annual average of 759 tons valued at £4,542 in the period 1924-1928 to 827 tons valued at £6,190 in the period under review.

III.—DETAILED ACCOUNT OF THE MINERALS OF GROUP I.

Antimony.

[L. L. FERMOR.]

A mining lease to work the well-known antimony-ores (stibnite with oxides) near the Shigri glacier in Lahaul, Punjab, was granted in 1904 to Colonel R. H. F. Rennick. The stibnite lodes are associated with gneissose granite and are situated at an elevation of 13,500 feet; to reach the locality it is necessary to cross the Hamta pass (14,500 feet). Work is possible for two or three months only in the year and labour and supplies have to be brought from the nearest village, 3½ marches away. In spite of these difficulties, however, Colonel Rennick succeeded in 1905 in shipping over 400 *maunds* (15 tons) of stibnite to England, making use of migratory flocks of sheep as transport. Since then further quantities were quarried and the deposits are thought to be extensive enough to yield 200 to 400 *maunds* of stibnite a year, but no further shipments were made on account of the low price of star regulus. The stibnite has yielded 6 dwts. of gold per ton. Galena and blende are also found in the same locality, the former being argentiferous. No production from this area has been reported since the quinquennium 1904-08.

Shigri.

The existence of an antimony deposit of considerable size in the Mong Hsu State, one of the Southern Shan States, was considered to be indicated by the return, amongst the mineral statistics for Burma for 1908, of an output, under a mining lease held by Mr. W. R. Hillier of Lashio, of 1,000 tons of antimony-ore, of which 11 tons were sent to London for assay and valuation. The output from the Southern Shan States in the following year was recorded as 2½ tons, since when there have been no returns. Further details regarding these deposits have been published in the *Records* of this department by Mr. H. C. Jones,

Southern Shan States.

who concludes that none of them appears to be large or of much economic value[1].

Amherst district, Northern Shan States and other localities.

In 1905, stibnite with cervantite was found in the Northern Shan States[2], and in 1917 Mr. H. C. Jones examined several antimony deposits in the Southern Shan States. The minerals found were stibnite and its oxidised derivatives valentinite and cervantite. None of the deposits proved to be of economic value[3]. The lead slags at Shekran in Jhalawan, Baluchistan, have been found to be antimonial[4]. The tetrahedrite found in the Sleemanabad copper lodes[5] is also highly antimonial. A few pounds of antimony-ore were recorded from the Jhelum district, Punjab, for the years 1914 to 1918, but no output has been reported since. Stibnite has for many years been known to exist in the Amherst district of Burma. In response to a considerable demand for antimony during the year 1916, the supply from this district, derived from two or three localities, was increased to 1,000 tons, but fell to 105 tons in 1917 and to *nil* in 1918. In 1917, Dr. A. M. Heron investigated these occurrences and concluded that some of them offered prospects of profitable exploitation ; a description of his work has been published in the *Records* of this department[6]. During the quinquennial period 1924-1928, 988 tons of antimony-ore, valued at Rs. 23,833, were produced in the Amherst district. In the present period 1929-1933, there was an output from the same district of 77 tons valued at Rs. 988 (£74) in 1929 and 3 tons valued at Rs. 60 (£4) in 1930, since when no output has been recorded. There was a small output of antimony-ore from Mysore in 1916 to 1918, since when production has ceased. Since 1924, antimonial lead has been obtained as a bye-product in the refining of lead at the Namtu smelter of the Burma Corporation. The yield during the period 1924-1928 averaged annually 1,020 tons, valued at Rs. 2,72,131 (£20,176). The yield in 1929 was 1,200 tons valued at Rs. 3,37,101 (£25,157), in 1930 1,700 tons valued at Rs. 3,54,994 (£26,296), in 1931 1,505 tons valued at Rs. 1,99,545 (£14,781), in 1932, 642 tons valued at Rs. 88,140 (£6,627), and in 1933 1,485 tons valued at Rs. 2,39,363 (£17,797), giving an

[1] *Rec. Geol. Surv. Ind.*, LIII, pp. 44-50, (1921).
[2] L. L. Fermor, *op. cit.*, XXXIII, p. 234, (1906).
[3] *Op. cit.*, LIII, p. 44, (1921).
[4] G. H. Tipper, *op. cit.*, XXXV, p. 51, (1907).
[5] L. L. Fermor, *op. cit.*, XXXIII, p. 62, (1906).
[6] *Op. cit.*, LIII, p. 34, (1921).

annual average for the period of 1,306 tons valued at Rs. 2,43,829 (£18,132). This product contains approximately 72 to 77 per cent. of lead, 21 to 24 per cent. of antimony and from 4 to 8 oz. of silver to the ton, and is exported for further treatment.

Chromite.

[L. L. Fermor.]

Occurrences of chromite in India are usually associated with serpentine and rocks of the peridotite family, and are known in Baluchistan, in Mysore, in the Singhbhum district of Bihar and Orissa, near Salem in Madras, and in the Andaman Islands. Serpentine and peridotite are found in large quantities in the Minbu district of Burma, in Manipur[1] and further north in the direction of Sarameti peak in the heart of the Arakan Yoma[2]; the chances of discovering chromite in the last-mentioned locality are considered to be good, whilst reports of chromite in the Minbu district have been received. The deposits at Karuppur in the 'Chalk Hills' near Salem have been known for a long time, and attempts were made many years ago to work them, but were given up. The mineral is found in very thin veinlets lying either amongst the magnesite or between the magnesite and the wall of the magnesite vein. Veins of chromite of some size must, however, occur somewhere in these hills, for in many of the streams pieces of the mineral ranging up to a foot across have been picked up[3]. The ore, of which some 100 tons were removed during the earlier half of the last century, yielded on analysis 49 per cent. of Cr_2O_3. According to Holland, the chromite is here associated with intrusions of dunite. A small vein of chromite, 4 inches thick, crops out in the Kanjamalai hill near by.

Blocks of chromite were found near the village of Chakargaon near Port Blair in the Andaman Islands, but the mineral was not

[1] R. D. Oldham, *Mem. Geol. Surv. Ind.*, XIX, pp. 224-225, (1883).
[2] E. H. Pascoe, *Rec. Geol. Surv. Ind.*, XLII, p. 258, (1912).
[3] C. S. Middlemiss, *op. cit.*, XXIX, p. 34, (1896).

found *in situ* and appeared to be confined to one spot; no attempt has been made to work it[1]. Chromite has been found in microscope slides of peridotites from the serpentine series of the Middle Andaman during a recent survey, but no occurrence of economic value was met with[2].

Baluchistan.

Chrome iron-ore was noted in Baluchistan by Vredenburg in 1901, who reported its occurrence in segregated masses of serpentine along the hills bordering the Zhob valley and in the upper valley of the Pishin river. In one spot, some two miles east of Khanozai, a mass of almost pure ore measuring about 400 feet in length and 5 feet in breadth, was found. A comprehensive study of the deposits of the Khanozai (Quetta-Pishin district) and the more important Hindubagh (Zhob) neighbourhoods in 1916 showed that the chromite, which is of high grade, occurs as veins and irregularly segregated masses in serpentine formed by the alteration of enstatite-peridotites (saxonites) of Upper Cretaceous age[3]. Work was commenced in 1903, the production for the first year being returned as 284 tons. The industry received a special impetus during the Great War and the output rose in 1918 to nearly 23,000 tons. In 1919 it was affected by the general slump and fell to about 13,200 tons. In 1920 it recovered itself, and the average annual output for the five years 1919-1923 amounted to 20,358 tons. In the succeeding quinquennium 1924-1928 the average annual output fell to 17,855 tons. In the present quinquennium there was a marked revival to an output of 25,387 tons in 1930, followed by a fall to only 228 tons at the depth of the slump in 1932. There was a small recovery in 1933, and the average for the period was 11,682 tons. This ore is exported from Karachi.

Mysore.

In Mysore State chromite occurs in the districts of Hassan, Mysore, Kadur and Shimoga. It has been worked in the first three districts only, the production for 1907, the first year of work, being 11,029 tons. The output, which had sunk to *nil* in 1910, 1911 and 1912, rose like that of Baluchistan during the war and owing to the vigour of Messrs. Oakley, Bowden and Company, who held a prospecting license, reached the high figure of 33,740 tons, much of it high-grade ore,

[1] *Rec. Geol. Surv. Ind.*, XVI, p. 204, (1883) and XVIII, p. 83, (1885).
[2] E. R. Gee, *op. cit.*, LIX, pp. 214, 231, (1926).
[3] L. L. Fermor, *op. cit.*, XLVIII, p. 12, (1917).

TABLE 11.—*Production of Chromite during the years 1929 to 1933.*

PROVINCE.	1929		1930		1931		1932		1933		*Average.*	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Baluchistan—												
Zhob . .	17,905	*2,66,761*	25,387	*3,77,980*	12,183	*1,81,291*	228	*3,420*	2,702	*40,530*	11,682	*1,73,996*
Bihar and Orissa—												
Singhbhum .	3,149	*68,440*	5,101	*99,222*	2,749	*37,269*	7,638	*1,08,972*	7,068	*1,01,904*	5,141	*83,162*
Mysore State—												
Hassan . .	22,799	*3,71,936*	13,106	*2,26,975*	1,888	*33,153*	2,812	*18,421*	3,479	*40,427*	8,817	*1,38,182*
Mysore . .	5,712	*1,34,632*	7,090	*1,63,279*	3,087	*63,313*	7,187	*1,44,862*	2,277	*40,384*	5,071	*1,09,294*
TOTAL . .	**49,565**	*8,41,769*	**50,684**	*8,67,456*	**19,913**	*3,15,026*	**17.865**	*2,75,675*	**15,526**	*2,23,245*	**30,711**	*5,04,634*
Total value in sterling.		*£62,818* (£1 = Rs. 13·4)		*£64,256* (£1 = Rs. 13·5)		*£23,335* (£1 = Rs. 13·5)		*£20,727* (£1 = Rs. 13·3)		*£16,785* (£1 = Rs. 13·3)		*£37,584*

in 1918. In 1919, 22,372 tons were raised, but a slump ensued in 1920 and 1921 to an output of only 3,082 tons in 1922, followed by a smart recovery in 1923 to 29,009 tons, giving an annual average for the period of 13,035 tons. The following quinquennium 1924-1928 witnessed an average annual production of 23,833 tons. During the present quinquennium, 1929-1933, the output fell from 28,511 tons in 1929 to 4,975 tons in 1931 with a subsequent slight recovery, the average for the period being 13,888 tons. By far the larger part of the Mysore chromite comes from the Hassan district, but there is also a continuous output from the Mysore district, and in 1932 with an output of 7,187 tons this exceeded the output of Hassan for that year. Chromite seems to have been first found in Mysore State by Mr. H. K. Slater, who discovered a rock shewing grains of chromite in a talcose matrix near Harenhalli in the Shimoga district[1]. Even the richest specimens did not indicate more than 35 to 40 per cent. of Cr_2O_3.

Bihar and Orissa.

A geological survey of the chromite area to the west of Chaibassa in Singhbhum, discovered by Mr. R. Saubolle in 1907, has shewn that the ore occurs as bed-like veins and as scattered granules in serpentinised saxonites and dunites forming laccolitic intrusions several hundred feet thick in Dharwar slates and slaty shales As in Baluchistan, the chromite is of primary (magmatic) origin and contemporaneous with the peridotites. The subsequent serpentinisation of the peridotites has been accompanied by widespread silicification with the production of marginal zones of chert. The ore-bearing horizon is unusually persistent over a considerable distance, but the total amount of ore does not appear to be large. As exported, the ore carries 50 per cent. of Cr_2O_3 and upwards, but the possibility of concentrating ores of lower grade may be worth consideration.[2] The output from Singhbhum has been small but steady and averaged 1,611 tons annually during the quinquennium 1919-1923, and 2,104 tons during the quinquennium 1924-1928. But during the last two years 1932 and 1933 of the present quinquennium, the output has been over 7,000 tons annually and the average for the quinquennium has been 5,141 tons.

[1] *Rec. Mysore Geol. Dept.*, II, p. 120, (1898-99); *Rep. Chief Inspect. Mines, Mysore*, 1906-07, p. 36.

[2] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 34, (1909); *ibid.*, L, p. 10, (1919); *Proc. As. Soc. Beng.*, N. S., XV, p. clxxxiii, (1919).

Coal.

[CYRIL S. FOX.]

Roughly 160 years have elapsed since the first efforts were made in 1774, in the time of Warren Hastings, to utilise Indian coal for public purposes. It is only since about 1815 that mining operations have been more or less sustained. The discovery and development of various coalfields, irregular at first owing to the difficulties of transport and the uncertainty of demand, has continued since 1829. Between the years 1882 and 1919 Indian coal production increased steadily—being somewhat accelerated during the war period 1914-1918. The highest output of coal recorded from Indian mines is that of 1930, when the production totalled 23,803,048 tons. With the cessation of the war in 1918, the various collieries were in a condition to meet increased demands. There were all the potentialities of a slump, but Indian coal vendors were to some extent fortunate in that the slump in price did not immediately accompany the diminished demand. The long expected fall in prices began in 1923 and has continued to 1933. Although the output of coal improved till 1930 it has fallen since and the total value of the coal has decreased year by year owing to the severe fall in the price of coal.

Production.

During the previous period, 1924-1928, the production fluctuated between narrow limits with an average annual total of 21,540,607 tons. During the period under review, the output reached 23,803,048 tons in 1930 and then fell steadily to 19,789,163, with an annual average for the period of 21,776,153 tons. *See* Table 12 for the annual figures of production and value, and Table 14 for the distribution according to provinces.

Burma has ceased to be a producer of coal. The production of Baluchistan has fallen somewhat appreciably. Assam shows a steady decline since 1929. The demand for Punjab coal has increased considerably. Hyderabad has had a fluctuating output as new pits were being sunk and a new area opened up. The rise in output from Central India is due to better management. In the Central Provinces there has been a general increase in the coal trade due to the advantage on freight to the Bombay markets. In the case of the Damuda

valley coalfields there has been a marked decrease in total production and many small collieries, engaged in working the poorer grade seams, have been obliged to close down.

TABLE 12.—*Production and value of Coal during the years 1924 to 1933.*

Year.	Quantity.	Total value at the mines.		*Average value per ton at the mines.*	
	Tons.	Rs.	£	Rs. A.	*s.* *d.*
1924 . . .	21,174,284	14,96,53,419	10,766,433(*a*)	7 1	*10 2* (*a*)
1925 . . .	20,904,377	12,64,00,908	9,503,828(*b*)	6 1	*9 1* (*b*)
1926 . . .	20,999,167	10,14,99,634	7,574,599(*c*)	4 13	*7 2* (*c*)
1927 . . .	22,082,336	9,48,70,013	7,079,852(*c*)	4 5	*6 5* (*c*)
1928 . . .	22,542,872	8,84,95,027	6,604,106(*c*)	3 15	*5 11* (*c*)
1929 . . .	23,418,731	8,93,59,124	6,668,591(*d*)	3 14	*5 9* (*d*)
1930 . . .	23,803,048	9,26,25,323	6,861,134(*e*)	3 14	*5 9* (*e*)
1931 . . .	21,716,435	8,26,98,364	6,125,804(*e*)	3 13	*5 8* (*e*)
1932 . . .	20,153,387	6,80,91,801	5,119,684(*f*)	3 6	*5 1* (*f*)
1933 . . .	19,789,163	6,11,77,739	4,599,830(*g*)	3 2	*4 8* (*g*)

(*a*) Rupee = 1*s*. $5\frac{1}{4}$*d*. (*b*) Rupee = 1*s*. 6*d*. (*c*) Rupee = 1*s*. 6*d*.
(*d*) Rupee = 1*s*. $5\frac{7}{8}$*d*. (*e*) Rupee = 1*s*. $5\frac{13}{16}$*d*. (*f*) Rupee = 1*s*. $6\frac{1}{16}$*d*
(*g*) Rupee = 1*s*. $6\frac{1}{32}$*d*.

The pit's month value province by province is shown in Table 15, almost all provinces showing a serious fall during the quinquennium.

Pit's mouth value.

In the following Table 13, the average value of the coal at the pit's mouth, obtained from both Bengal and Bihar and Orissa figures, is compared with the average declared export value per ton.

TABLE 13.—*Export value compared with pit's mouth value for the years 1924 to 1933.*

Year.	Declared export value per ton.	Value at the pit's mouth, per ton.
	Rs. A.	Rs. A.
1924	16 9	7 1
1925	15 0	6 0
1926	12 4	4 12
1927	12 2	4 2
1928	11 9	3 12
1929	10 6	3 10
1930	11 4	3 12
1931	11 3	3 11
1932	9 15	3 3
1933	9 10	2 15

TABLE 14.—*Output of Indian Coal by Provinces for the years 1924 to 1928 and 1929 to 1933.*

Province	1924	1925	1926	1927	1928	Total 1924 to 1928	1929	1930	1931	1932	1933	Total 1929 to 1933
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Assam (a)	334,842	318,842	301,061	323,342	298,089	1,576,176	322,515	359,040	275,021	210,035	194,154	1,360,765
Baluchistan (b)	40,557	34,797	15,586	14,444	17,931	123,315	16,222	15,894	16,554	18,928	11,462	79,060
Bengal	5,031,655	4,913,852	5,137,688	5,554,990	5,639,993	26,278,178	5,065,104	6,316,528	5,810,184	5,782,603	5,691,189	29,565,608
Bihar and Orissa (c)	14,105,529	13,938,509	13,955,775	14,517,866	14,827,453	71,345,132	15,133,144	15,064,425	13,532,794	11,847,216	11,257,984	66,835,563
Burma	255	25	..	..	..	280	..	..	..	..	..	..
Central India	235,298	219,106	216,708	217,661	218,750	1,107,523	203,132	193,233	226,928	240,488	252,768	1,118,549
Central Provinces (d)	679,081	708,554	635,252	666,758	732,353	3,421,998	882,331	955,888	1,004,391	1,163,096	1,500,911	5,506,617
Hyderabad	644,775	667,877	637,779	707,213	734,765	3,392,409	815,875	812,298	757,575	781,121	753,402	3,920,271
Punjab	80,422	74,662	68,043	62,704	46,152	331,933	43,136	50,619	54,840	72,857	94,099	315,551
Rajputana (Bikaner).	21,870	28,153	31,275	17,358	27,380	126,042	35,275	35,123	38,148	37,043	33,194	178,783
Total	21,174,284	20,904,377	20,999,167	22,082,336	22,542,872	107,703,036	23,418,734	23,803,048	21,716,435	20,153 387	19,789,163	108,880,767

TABLE 15.—*Average pit's mouth value (per ton) of Coal extracted from the mines in each Province during the years 1924 to 1928 and 1929 to 1933.*

Province.	1924	1925	1926	1927	1928	Average 1924 to 1928	1929	1930	1931	1932	1933	Average 1929 to 1933
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Assam (a)	8 12 11	8 10 1	7 13 9	12 11 7	12 12 2	10 2 6	12 10 8	10 13 4	11 4 5	10 12 7	9 3 9	10 15 4
Baluchistan (b)	15 14 2	13 0 9	9 7 5	8 6 4	9 2 4	11 3 0	8 13 1	7 11 9	8 1 9	7 14 3	6 14 7	7 14 3
Bengal	8 0 11	6 12 6	5 3 7	4 7 0	3 15 8	5 11 2	3 13 3	3 15 2	3 13 1	3 4 0	2 13 9	3 8 8
Bihar and Orissa (c)	6 11 9	5 11 3	4 9 6	3 15 11	3 10 6	4 15 0	3 8 10	3 10 8	3 9 8	3 3 1	2 15 3	3 6 4
Central India	5 12 11	4 9 3	4 9 1	4 6 3	3 14 0	4 10 8	3 13 6	4 1 2	4 4 5	4 3 0	3 14 7	4 0 11
Central Provinces (d)	6 1 5	6 3 2	5 4 2	4 6 7	4 3 4	5 3 9	4 4 3	4 4 6	4 0 10	3 13 1	3 12 1	4 0 7
Punjab	8 11 5	8 3 5	7 4 9	7 2 6	6 11 8	7 9 11	6 11 6	6 1 2	4 13 4	5 4 2	4 11 9	5 8 5
Rajputana	7 1 4	6 15 2	6 3 9	6 14 4	6 12 5	6 12 7	5 10 8	4 9 0	3 14 8	4 1 0	4 6 8	4 8 5

(a) Includes Khasi and Jaintia Hills. (b) Includes Kalat State. (c) Includes Talchir State. (d) Includes Korea and Raigarh States.

TABLE 16.—*Production of Coal in the four largest British Dependencies for the years 1923 to 1932.*

Countries.	1923		1924		1925		1926		1927	
	Long Tons	*Per cent. of British output.*	Long Tons	*Per cent. of British output.*	Long Tons	*Per cent. of British output.*	Long Tons	*Per cent. of British output.*	Long Tons	*Per cent. of British output.*
India	19,653,803	*5·32*	21,174,284	*6·39*	20,904,377	*6·83*	20,999,167	*10·89*	22,082,336	*6·90*
Australia	12,631,000	*3·73*	13,757,500	*4·16*	13,626,777	*4·45*	13,275,000	*6·88*	13,523,000	*4·23*
Canada	15,170,000	*4·49*	8,995,000	*2·41*	8,411,000	*2·77*	(a) 14,713,000	*7·62*	(a) 15,560,000	*4·86*
South Africa . . .	11,123,000	*3·29*	11,153,000	*3·57*	11,607,000	*3·79*	12,746,000	*6·69*	12,382,000	*3·87*
Total for British Empire†	**338,000,000**	..	**331,000,000**	.	**306,000,000**	..	**193,000,000**	..	**320,000,000**	..

(a) Including lignite. † Approximate.

Countries.	1928		1929		1930		1931		1932	
	Long Tons	*Per cent. of British output.*	Long Tons	*Per cent. of British output.*	Long Tons	*Per cent. of British output.*	Long Tons	*Per cent. of British output.*	Long Tons	*Per cent. of British output.*
India	22,542,872	*7·37*	23,418,734	*7·16*	23,803,048	*7·70*	21,716,435	*7·84*	20,153,387	*7·69*
Australia	11,840,000	*3·87*	10,365,000	*3·17*	9,531,000	*3·09*	8,401,000	*3·03*	(b) 8,586,000	*3·20*
Canada	(a) 15,682,000	*5·12*	(a) 15,622,000	*4·80*	(a) 13,287,000	*4·30*	(a) 10,481,000	*3·95*	(a) 10,481,000	*4·00*
South Africa . . .	12,407,000	*4·05*	12,813,000	*3·92*	12,029,000	*3·89*	10,710,000	*3·86*	9,764,000	*3·72*
Total for British Empire†	**306,000,000**	..	**327,000,000**	..	**309,000,000**	..	**277,000,000**	..	**262,000,000**	..

(a) Including lignite. (b) Provisional. † Approximate.

The position of India as a coal-producer as compared with Australia, Canada and South Africa is illustrated by Table 16, and with reference to Japan by Table 17. As in previous periods the Indian production was substantially greater than that of each of the Dominions and less than that of Japan.

Comparison of India with British Dependencies and Japan.

TABLE 17.—*Comparison of Indian and Japanese Coal statistics.*

Year.	PRODUCTION.		IMPORTS.		EXPORTS.		Quantity retained for consumption in Japan.
	India.	Japan.	India (*a*).	Japan.	India (*a*).	Japan.	
1885 .	1,204,221	1,294,000	790,980	12,876	750	191,802	1,115,074
1890 .	2,168,521	2,566,551	784,664	12,301	26,649	853,720	1,725,132
1895 .	3,540,019	4,738,861	761,996	68,931	81,126	1,376,068	3,426,724
1900 .	6,118,692	7,369,068	135,649	108,593	490,491	2,402,785	5,074,876
1905 .	8,417,739	11,407,799	197,784	329,495	783,051	2,507,527	9,229,767
1909 .	11,870,064	14,732,970	490,421	129,858	563,940	2,798,563	12,064.265
1913 .	16,208,009	20,973,384	644,934	567,502	759,210	3,808,394	17,732,492
1918 .	20,722,493	27,578,952	54,346	755,452	74,466	2,161,727	26,172,677
1919 .	22,628,037	30,767,537	48,675	688,402	508,635	1,968,543	29,487,396
1920 .	17,962,214	28,775,369	39,727	796,892	1,224,872	2,095,305	27,476,956
1921 .	19,302,947	26,220,617	1,090,749	777,255	277,852	2,387,709	24,610,163
1922 .	19,010,986	27,256,505	1,220,639	1,168,524	150,055	1,690,699	26,734,330
1923 .	19,656,883	28,483,571	624,918	1,658,783	182,606	1,549,004	28,593,350
1924 .	21,174,284	29,626,902	463,716	1,979,978	272,436	1,711,292	29,895,588
1925 .	20,904,377	30,953,817	483,160	1,740,500	267,026	2,694,515	29,999,802
1926 .	20,999,167	30,930,210	193,908	2,012,526	661,711	2,590,316	30,352,420
1927 .	22,082,336	33,001,037	243,603	2,660,556	620,135	2,173,449	33,488,144
1928 .	22,542,872	33,325,406	210,186	2,734,931	670,384	2,150,432	33,909,905
1929 .	23,418,734	33,716,762	218,560	3,203,232	706.232	2,011,402	34,908,592
1930	23,803,048	30,880,459	217,029	2,650,280	506,521	2,097.269	31,433,470
1931 .	21,716,435	27,545,251	88,035	2,650.144	440,021	1,515,808	28,679,587
1932 .	20,153,387	27,602,517	47,544	2,673,222	521,908	1,365,971	28,909,768

(*a*) Excludes Government stores.

Nearly 98 per cent. of the Indian output of coal is consumed in this country (*see* Table 18), and as the production of coal has increased so the consumption has grown. In 1929 and 1930 the amount consumed in India exceeded the figure for 1919. The largest

Relation of consumption to production.

consumers (*see* Table 19) of Indian coal are the railways—a decrease of nearly 800,000 tons being evident between 1927 and 1932. There has been a falling off in the demand from jute mills and bunker coal but this is almost exactly offset by the increased tonnage for cotton mills. Perhaps the most serious decrease is in the supply for metallurgical purposes, and iron and steel smelting in particular. The requirements of these iron works are now far less than what they were five years ago. There has been a slight improvement as regards the consumption of coal at collieries—a smaller quantity being now reported, but this is largely due to several collieries having closed down. The amount of coal recorded from other forms of industrial and domestic consumption is greater than the figure of five years ago. The increased quantity of coal carried by the railways is an indication of the larger demand for coal in India (*see* Table 21).

TABLE 18.—*Relation of consumption to production* (*a*).

Year.	Total. consumption of coal in India.	CONSUMPTION OF INDIAN COAL IN INDIA.	
		Quantity.	*Percentage of Indian production.*
	Tons.	Tons.	
1924	21,463,351	20,966,836	*99·0*
1925	21,203,429	20,687,449	*98·9*
1926	20,593,497	20,380,465	*97·1*
1927	21,754,749	21,503,835	*97·4*
1928	22,145,212	21,913,056	*97·2*
Average .	*21,432,048*	*21,090,328*	*97·9*
1929	22,922,434	22,689,843	*96·9*
1930	23,576,309	23,340,578	*98·1*
1931	21,372,884	21,272,900	*98·0*
1932	19,693,406	19,631,950	*97·4*
1933	19,450,326	19,361,875	*97·8*
Average .	*21,403,072*	*21,259,429*	*97·6*

(*a*) The consumption of coal is assumed to be production *plus* imports *minus* exports. In the exports and imports, a ton of coke is taken to be equivalent to 2 tons of coal. The imports exclude Government stores.

TABLE 19.—*Estimated consumption of Coal in India during the years 1927 and 1932.*

—	Estimated consumption in 1927.	*Per cent. of total.*	Estimated consumption in 1932.	*Per cent. of total.*
	Tons.		Tons.	
Railways . . .	(*a*) 7,259,000	*33·5*	(*a*) 6,443,000	*32·7*
Admiralty and Royal Indian Marine.	27,000	*0·1*	30,000	*0·2*
Bunker coal . .	1,317,000	*6·1*	1,077,000	*5·5*
Cotton mills . .	830,000	*3·8*	1,361,000	*6·9*
Jute mills . . .	935,000	*4·3*	653,000	*3·3*
Iron industry (including engineering workshops).	5,260,000	*24·2*	3,997,000	*20·3*
Port Trusts . .	205,000	*0·9*	135,000	*0·7*
Inland steamers . .	636,000	*2·9*	579,000	*3·0*
Brick kilns, potteries, cement works, etc.	565,000	*2·6*	(*b*) 669,000	*3·4*
Tea gardens . .	223,000	*1·0*	203,000	*1·0*
Paper mills . .	156,000	*0·7*	142,000	*0·7*
Collieries and wastage .	2,208,000	*10·2*	2,015,000	*10·2*
Other forms of industrial and domestic consumption.	2,085,000	*9·7*	(*c*) 2,375,000	*12·1*
TOTAL .	**21,706,000**	*100·0*	**19,679,000**	*100·0*

(*a*) For the official years 1927-28 and 1932-33.
(*b*) Estimate on the basis of the census figures for 1916 and 1917.
(*c*) Domestic consumption in Calcutta and its neighbourhood was estimated by the Coal Controller in 1917 at 200,000 tons per year.

TABLE 20.—*Coal consumed on Indian Railways during the years 1923-24 to 1932-33.*

Year.	INDIAN COAL.		FOREIGN COAL.		TOTAL CONSUMPTION.
	Quantity.	*Per cent. of total.*	Quantity.	*Per cent. of total.*	
	Tons.		Tons.		Tons.
1923-24 . .	6,060,693	*98·0*	123,361	*2·0*	**6,184,054**
1924-25 . .	6,605,446	*99·5*	33,493	*0·5*	**6,638,939**
1925-26 . .	6,550,241	*99·8*	12,835	*0·2*	**6,563,076**
1926-27 . .	6,433,284	*99·9*	4,597	*0·1*	**6,437,881**
1927-28 . .	7,257,623	*99·9*	1,804	*0·1*	**7,259,427**
Average .	*6,581,457*	*99·4*	*35,218*	*0·6*	***6,616,675***
1928-29 . .	7,438,969	*99·9*	1,440	*0·1*	**7,440,409**
1929-30 . .	7,581,613	*99·9*	1,765	*0·1*	**7,583,378**
1930-31 . .	7,518,925	*99·9*	6,320	*0·1*	**7,525,245**
1931-32 . .	6,628,465	*100·0*	308	..	**6,628,773**
1932-33 . .	6,443,275	*100·0*	51	..	**6,443,326**
Average .	***7,122,249***	***99·9***	***1,977***	***0·1***	***7,124,226***

TABLE 21.—*Coal carried for the Public in India and for Foreign Railways during the years 1918-19 to 1932-33.*

Year.	Coal carried on Indian Railways.	Earnings of Railways from coal traffic.
	Millions of Tons.	Rs. Million.
1918-19	23·25	88·04
1919-20	21·40	79·08
1920-21	21·86	82·14
1921-22	18·78	72·99
1922-23	20·37	85·30
1923-24	19·85	82·23
1924-25	22·85	91·65
1925-26	22·01	89·54
1926-27	23·91	90·37
1927-28	25·78	95·03
1928-29	25·41	94·53
1929-30	27·19	95·16
1930-31	25·10	88·20
1931-32	23·03	81·25
1932-33	21·90	81·65

Imports and exports.

When we study the data on Indian imports and exports of coal there is seen to be a very satisfactory balance of trade in favour of India as regards tonnage (*see* Table 22). The imports, a little over 67,000 tons in 1933, are roughly $\frac{1}{7}$ of the exports. It is believed that this satisfactory trend of the coal trade is due to the strict observance of quality in the export of Indian coal. And to the same factor must be ascribed the gradual replacement of foreign coal by Indian coal in the Indian market. The only serious competitor in India is the coal imported from South Africa, particularly from Rhodesia *viâ* Beira. It appears likely that, with careful attention to quality and the reduction in freight recently granted by the State Railways, the imports of foreign coal will be further reduced by substitution from

Indian sources. The fall in the total export trade can be gauged by the imports into Ceylon (*see* Table 26) and the Straits Settlements (*see* Table 27). In the former case, India and South Africa are each striving to monopolise the trade. In the Straits Settlements, the market is supplied from several sources, but South Africa and Japan have a considerable share in the trade, with Dutch Borneo and Sumatra also attractively engaged. In this market, Indian coals have been imported in rapidly diminishing quantities and no supplies despatched from Sumatra. The trend of the trade shows that Indian coal is losing ground to the coals from Japan and South Africa.

TABLE 22.—*Indian imports (a) and exports (b) of Coal during the years 1914 to 1933.*

Year.	Imports.	Exports.
	Tons.	Tons.
1914	418,758	579,746
1915	190,654	753,042
1916	34,033	881,741
1917	44,818	408,117
1918	54,346	74,466
1919	48,675	508,537
1920	39,727	1,224,758
1921	1,090,749	275,571
1922	1,220,639	77,111
1923	624,918	136,575
Average 1914-1923	*376,732*	*491,966*
1924	463,716	206,483
1925	483,160	216,090
1926	193,908	617,563
1927	243,603	576,167
1928	210,186	626,343
Average 1924-1928	*318,914*	*448,529*
1929	218,560	726,610
1930	217,029	461,188
1931	88,035	441,249
1932	47,544	519,483
1933	67,330	426,176
Average 1929-1933	*127,699*	*514,941*

(*a*) Excluding Government stores but including coke.
(*b*) Excluding bunker coal and Government stores but including coke and patent fuel.

TABLE 23.—*Origin of Foreign Coal (a) imported into British India.*

Year.	United Kingdom.	Australia.	Union of South Africa.	Japan.	Portuguese East Africa.	Other Countries.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1924 . . .	109,916	21,803	185,141	2,384	141,537	2,935	**463,716**
1925 . . .	124,111	7,495	201,189	7,470	130,312	9,583	**483,160**
1926 . . .	35,142	13,323	89,911	7,229	46,194	2,109	**193,908**
1927 . . .	55,903	11,017	133,827	5,869	29,314	7,673	**243,603**
1928 . . .	40,233	5,321	129,734	380	31,577	2,941	**210,186**
Average .	*73,061*	*11,792*	*148,560*	*4,666*	*75,787*	*5,048*	*318,914*
1929 . . .	33,786	1,043	176,376	1,216	150	5,980	**218,560**
1930 . . .	20,258	1,190	186,029	1,512	5,061	2,979	**217,029**
1931 . . .	29,974	3,400	48,716	45	..	5,900	**88,035**
1932 . . .	19,811	4,070	20,418	782	..	2,463	**47,544**
1933 . . .	11,174	4,248	45,258	435	..	6,215	**67,330**
Average .	*23,001*	*2,790*	*95,359*	*798*	*1,042*	*4,709*	*127,699*

(*a*) Excluding Government stores but including coke.

TABLE 24.—*Exports of Indian Coal (a).*

	1924	1925	1926	1927	1928	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
Aden	7,423	..	59,312	2	..	*13,353*
Mauritius	..	1,665	..	1,555	1,700	*984*
Straits Settlements . .	17,763	18,754	117,469	147,405	73,389	*74,956*
Sumatra	..	612	4,049	15,568	..	*4,046*
Hongkong	..	..	2,085	8,752	110,701	*24,308*
Ceylon	170,701	194,189	243,263	341,352	352,602	*260,421*
Other countries . . .	10,596	870	(*b*)191,355	61,533	87,951	*70,461*
Total Exports .	**206,488**	**216,090**	**617,563**	**576,167**	**626,343**	*448,529*
Value in Rs.	34,19,098	32,44,091	79,33,216	69,76,113	72,47,597	*57,64,029*
Value in Sterling . . .	£245,978 (£1 = Rs. 13·9)	£243,917 (£1 = Rs. 13·3)	£592,033 (£1 = Rs. 13·4)	£520,605 (£1 = Rs. 13·4)	£540,865 (£1 = Rs. 13·4)	*£428,679*

(*a*) Excluding bunker coal and Government stores but including coke and patent fuel.
(*b*) Includes 105,711 tons shipped to Egypt and 51,363 tons shipped to the United Kingdom.

TABLE 24.—*Exports of Indian Coal*—contd.

	1929	1930	1931	1932	1933	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
Aden	7,439	1	39	2	..	*1,496*
Mauritius	2,171	..	3,187	2,517	..	*1,575*
Straits Settlements .	75,770	26,367	30,246	13,357	8,655	*30,879*
Sumatra	6,066	..	..	..	..	*1,213*
Hongkong	196,074	61,885	89,127	219,490	140,216	*141,359*
Ceylon	366,926	282,590	282,289	190,834	229,122	*270,352*
Other countries . . .	72,164	(*a*) 90,345	36,361	(*b*) 93,283	(*c*) 48,183	*68,067*
Total Exports .	**726,610**	**461,188**	**441,249**	**519,483**	**426,176**	*514,941*
Value in Rs.	75,57,332	51,87,917	49,32,725	51,76,864	41,10,471	*53,93,062*
Value in Sterling . . .	£563,980 (£1 = Rs. 13·4)	£384,290 (£1 = Rs. 13·5)	£365,387 (£1 = Rs. 13·5)	£389,238 (£1 = Rs. 13·3)	£309,058 (£1 = Rs. 13·3)	*£402,391*

(*a*) Includes 27,600 tons shipped to the United Kingdom.
(*b*) Includes 32,719 tons shipped to the United Kingdom, 29,043 tons to the Philippine Islands, and Guam and 23,956 tons to China.
(*c*) Includes 29,892 tons shipped to the United Kingdom and 11,469 tons to China.

TABLE 25.—*Quantity of coal, coke and patent fuel, exported from Calcutta to Indian Ports during the years 1924 to 1933.*

PORTS.	(*a*) 1924	1925	1926	1927	1928	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
Bombay	174,355	202,759	349,855	349,211	282,441	*271,724*
Sind	61,379	97,773	170,671	154,692	138,945	*124,692*
Madras	250,885	294,299	352,985	416,797	471,523	*357,298*
Burma	282,870	433,705	529,780	776,546	690,487	*542,678*
Bihar and Orissa . . .	205	37	3,866	1	1	*822*
Bengal	16,416	15,414	10,008	20,351	24,531	*17,344*
Indian ports not British .	..	7,341	60,585	42,692	87,054	*39,534*
TOTAL .	**786,110**	**1,051,328**	**1,477,750**	**1,760,290**	**1,694,982**	*1,354,092*

(*a*) For 9 months—April to December, 1924 ; figures for the months of January to March, 1924, are not available.

TABLE 25.—*Quantity of coal, coke and patent fuel, exported from Calcutta to Indian Ports during the years 1924 to 1933*—contd.

PORTS.	(a) 1929	1930	1931	1932	1933	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
Bombay	278,015	259,801	437,520	456,023	425,826	*371,337*
Sind	133,964	72,857	98,548	72,779	70,167	*89,663*
Madras	424,172	487,211	442,053	447,713	293,596	*418,949*
Burma	580,370	670,289	632,288	531,145	402,132	*581,245*
Bihar and Orissa . . .	40	299	109	100	330	*177*
Bengal	30,165	37,989	34,892	38,703	31,608	*34,671*
Indian ports not British .	93,289	88,869	104,579	164,796	167,374	*123,782*
TOTAL .	1,540,015	1,616,815	1,749,989	1,711,268	1,481,033	*1,619,824*

(a) For 9 months—April to December, 1929; figures for the months of January to March, 1929, are not available.

Looked at broadly, the question of the future of the Indian coal trade—its expansion both in volume and monetary value is most complex. The markets for coal outside India, on the Indian Ocean and western Pacific seaboard, do not absorb more than a small fraction of the Indian output, but they will be valuable to the Indian coal vendor until a better market can be obtained. The market seems to be uncertain beyond the limit of Ceylon. There is little doubt that greater expansion of the Indian coal trade could be brought about by the cultivation of a demand for coal as household and industrial fuel in this country. When it is remembered that the population of India is 300 millions and that barely 2 million tons of coal are used for household purposes the potentialities of this trade appear attractive. It is, however, well known that any considerable measure of success in this direction involves long and expensive effort. The people are poor, wood and dung are obtainable free, so that it would be unreasonable to expect them to use coal unless this were supplied free. There are some areas, Eastern Bengal and Berar, where a smokeless fuel will sell, and it is in these that a beginning could be made. At present only the inferior grade (high-ash) coals are used in the manufacture of smokeless fuel or soft coke. It is

Possibilities of expansion.

TABLE 26.—*Foreign coal imports of Ceylon for the years 1924 to 1933.*

ORIGIN OF THE COAL.	1924	1925	1926	1927	1928	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
United Kingdom	182,037	141,337	76,397	113,710	81,716	*119,039*
British India	167,890	204,680	224,132	337,400	335,194	*253,859*
British South Africa	310,762	321,442	326,930	260,831	203,026	*284,598*
Other countries	14,147	4,695	35,927	30,446	25,044	*22,112*
Total Imports	**675,136**	**672,154**	**663,386**	**742,387**	**644,980**	*679,608*

ORIGIN OF THE COAL.	1929	1930	1931	1932	1933	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
United Kingdom	98,031	103,113	41,998	32,678	44,190	*64,002*
British India	436,494	295,368	298,449	232,560	256,920	*303,958*
British South Africa	269,129	167,830	133,296	70,298	95,248	*147,160*
Other countries	8,891	700	20,525	14,510	8,558	*10,637*
Total Imports	**812,545**	**567,011**	**494,268**	**350,046**	**404,916**	*525,757*

TABLE 27.—*Foreign coal imports of the Straits Settlements for the years 1924 to 1933.*

Year.	From United Kingdom.	From British India.	From Australia.	From Japan.	From Union of South Africa.	From Dutch Borneo.	From Sumatra.	From other countries.	**Total.**
	Tons.	Tons.	Tons	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1924	44,178	6,955	79,497	52,969	265,799	80,613	55,750	109,454	**695,215**
1925	38,052	18,749	31,676	134,710	176,702	94,904	54,833	99,947	**649,573**
1926	12,283	111,013	14,759	236,611	163,148	124,165	60,658	75,557	**799,094**
1927	59,594	136,001	28,276	200,421	182,102	174,365	48,468	44,722	**873,949**
1928	56,463	71,235	19,443	147,385	235,123	167,553	53,415	56,762	**807,384**
Average 1924-28	*42,115*	*68,971*	*34,730*	*154,419*	*204,575*	*128,320*	*54,625*	*77,288*	*765,043*
1929	92,033	69,526	2,882	226,214	183,084	154,903	90,262	11,396	**830,300**
1930	42,643	32,291	11,256	203,597	161,842	112,944	86,731	34,132	**685,436**
1931	19,388	27,875	14,300	175,191	92,367	71,288	125,416	23,704	**549,528**
1932	41,655	10,978	1,480	224,564	133,241	30,199	84,320	11,972	**538,409**
1933	55,669	8,027	13,690	215,247	113,024	27,961	79,817	39,387	**552,823**
Average 1929-33	*50,278*	*29,739*	*8,722*	*208,963*	*136,711*	*79,459*	*93,309*	*24,118*	*631,299*

also true that the best quality coking coals are being used for steam raising purposes—in power stations and locomotives. It is probable that the successful application of pulverised fuel firing in boilers and cement kilns will lead to some economy in the use of coking coal. The adoption of low temperature distillation (carbonisation) of coal may, when commercially successful, be of considerable value to the Indian coal industry, but the fuel must be sold very cheaply. The only hope of success for this mode of treatment is the auxiliary process of hydrogenation, but for the success of this the 10-anna excise tax on benzol must be greatly reduced.

Geological Relations of Indian Coal.

Age of coalfields.

Coal in workable seams is known to occur in India at various horizons among the rocks of the Peninsula and in the Extra-Peninsular regions of Burma, Assam, the Himalaya, Punjab and Baluchistan. The most important coal seams are of course those in the Lower Gondwana (Permian) strata of the Peninsula and in the Tertiary (Eocene) rocks of Upper Assam. Roughly 98 per cent. of the Indian production of coal is obtained from the Lower Gondwana coal seams, and the remainder is obtained from rocks of Tertiary age. No coal is now obtained from the Jurassic strata of the Loi-an (Kalaw) field of the Southern Shan States nor from the Pleistocene lignites of Nam-ma and Lashio in the Northern Shan States of Burma. The geological age of the coalfields of India is shown below :—

Coalfield.	Geological Age.	
12. Nam-ma, etc., N. Shan States, Burma	Pleistocene.	Tertiary.
11. Makum, Nazira, Naga Hills, Up. Assam	Eocene.	
10. Cherrapunji, Khasia Hills, Assam		
9. Kalewa, Chindwin river, Burma		
8. Palana, Bikaner State, Rajputana		
7. Dandot, Punjab Salt Range .		
Makerwal, Punjab . .		
Khost, Sor Range, etc., Baluchistan		
6. Kalakot, Jammu State, Kashmir .		
5. Darenggiri, etc., Garo Hills, Assam		
4. Loi-an, S. Shan States, Burma .	Jurassic	Mesozoic.
3. Raniganj series seams of Raniganj and Jharia	Up. Permian	Lower Gondwana. (Permian).
2. Barakar series seams of Jharia and other Peninsular fields.	Lr. Permian.	
1. Karharbari seam, Giridih coalfield		

Typical analyses of coal from the above-mentioned fields are given below :—

Coalfield.	Moisture.	Volatile matter.	Fixed carbon.	Ash.
	Per cent.	Per cent.	Per cent.	Per cent.
12. Nam-ma, Burma . .	8·98	44·84	44·25	1·93(a)
" " . .	23·74	36·50	36·36	3·40(b)
11. Makum, Assam . .	2·04	42·27	54·27	1·21(c)
11. Nazira, Assam . .	4·35	48·00	45·70	1·95(d)
11. Naga Hills . . .	8·15	38·48	52·98	0·39(e)
10. Cherrapunji, Assam .	2·14	50·38	42·71	2·77
9. Kalewa, Burma . .	9·82	45·19	42·58	2·41(f)
8. Palana, Rajputana .	12·55	46·67	36·38	4·40(g)
7. Dandot, Punjab . .	6·13	36·81	47·17	9·89
7. Makerwal, Punjab . .	2·40	43·54	41·38	12·68(n)
7. Mach, Baluchistan .	10·71	41·43	45·68	2·18(h)
7. Khost, Baluchistan .	2·29	41·51	46·52	9·68
6. Kalakot, Jammu . .	0·43	12·45	78·12	9·00(i)
6. Kalakot, Jammu . .	4·14	15·92	68·26	11·68
5. Waimong, Garo Hills .	1·49	51·32	40·98	6·21(j)
5. Dogring, Garo Hills .	4·86	33·80	56·13	5·71(k)
4. S. Shan States, Burma .	1·22	29·88	62·51	6·39(l)
3. Raniganj, Ghusick .	7·55	34·80	52·60	12·60(m)
3. Raniganj, Dishergarh .	2·57	33·25	54·25	9·80(m)
2. Jharia, No. XVIII . .	1·80	28·80	59·30	11·90(m)
2. Jharia, No. XIV . .	1·27	22·85	64·70	12·45(m)
2. Jharia, No. XII . .	0·75	20·10	65·30	14·60(m)
2. Jharia, No. V-VI . .	0·65	14·10	66·20	19·80(m)
1. Giridih, Karharbari .	0·90	22·50	66·00	10·60

Remarks.—(a) Sp. Gr. 1·38, (b) As taken, (c) Namdang, (d) Borjan, (e) Wakching, (f) Sp. Gr. 1·32, (g) Dark-brown, (h) Picked, (i) Near Ber, (j) Coking, (k) Non-coking, (l) Coking, (m) Moisture free, Alipur Test House analyses, (n) Coking.

Geological origin of the coal.

Table 28 shows the origin of the coal produced during the years 1929 to 1933. From this it will be seen, by comparison with previous similar tables, that the output from the Gondwana coalfields has gradually become a slightly larger fraction of the total.

TABLE 28.—*Origin of Indian Coal raised during the years 1924 to 1933.*

	From Gondwana Strata.		From Tertiary Strata.		Total production.
	Tons.	*Per cent. of total.*	Tons.	*Per cent. of total.*	Tons.
1924 . .	20,696,338	*97·75*	477,946	*2·25*	**21,174,284**
1925 . .	20,447,898	*97·82*	456,479	*2·18*	**20,904,377**
1926 . .	20,583,202	*98·02*	415,965	*1·98*	**20,999,167**
1927 . .	21,664,488	*98·11*	417,848	*1·89*	**22,082,336**
1928 . .	22,153,314	*98·27*	389,558	*1·73*	**22,542,872**
Average .	*21,109,048*	*97·99*	*431,559*	*2·01*	*21,540,607*
1929 . .	23,001,586	*98·22*	417,148	*1·78*	**23,418,734**
1930 . .	23,342,372	*98·06*	460,676	*1·94*	**23,803,048**
1931 . .	21,331,872	*98·22*	384,563	*1·78*	**21,716,435**
1932 . .	19,814,524	*98·32*	338,863	*1·68*	**20,153,387**
1933 . .	19,456,254	*98·32*	332,909	*1·68*	**19,789,163**
Average .	*21,389,321*	*98·23*	*386,832*	*1·77*	*21,776,153*

The Gondwana coalfields.

The richest workable coal seams in India are of course those of the Lower Gondwana period in the coalfields of the Damuda valley and other areas in the Peninsula. In their type area, the Damuda or coal-bearing series is nearly 7,000 feet thick. In the Jharia field, in the lowest stage (Barakar) of this series, there are no less than eighteen workable seams, totalling nearly 200 feet of coal. In the upper stage (Raniganj), of the Raniganj field there are roughly six workable seams of a total thickness of, roughly, 50 feet of coal. In both stages the seams are interbedded between shales (usually below) and sandstones (frequently above). The sandstones are often coarse and conglomeratic, with, in many cases, the pebbles resting on the coal. There are numerous instances of current-bedding and overstepping of the sandstones and shales on to the coal seams. The seams are laminated and well-bedded, even when more than forty feet thick. When traced in one or other direction the coal seams are found to split or come together. It is not unusual to find a coal seam passing laterally into carbonaceous shale.

There is a considerable range in the variety of the coals obtained from the numerous seams in the Jharia coalfield. These differ in geological age, from Lower Permian, for the basal (numbers I to X) seams of the Barakar series, to Upper Permian, for the seams in the

Raniganj series of the same field. When these seams are compared with each other and with the seams of the Raniganj series in the Raniganj field, remarkable differences of character are found, which, to some extent, may be evident from the analyses given below :—

Gondwana Coals.[1]

——	Moisture.	Volatile matter.	Fixed carbon.	Ash.
Jharia. Barakar series.	Per cent.	Per cent.	Per cent.	Per cent.
Matiagara (II) . . . . Seam	0·65	14·2	68·0	17·8
Narkharki (V) . . . . "	0·65	14·1	66·2	19·7
Dhansar (VIII) . . . . "	1·0	17·3	61·57	21·13
Dhariajoba (X) . . . . "	1·0	19·0	62·4	13·6
Kenwadih (XII) . . . . "	0·75	20·1	65·3	14·6
Khas Jharia (XII) . . . . "	1·15	21·65	62·35	16·0
Bhuggutdih (XIV) . . . . "	1·27	22·85	64·7	12·45
Lodna (XIV) . . . . "	1·6	24·6	61·0	14·4
Bhagaband (XVI) . . . . "	1·3	24·5	60·2	15·3
Bhagaband (XVII) . . . . "	1·6	27·2	59·6	13·2
Bhutgooria (XVII) . . . . "	2·0	28·13	58·85	13·02
Noonudih (XVIII) . . . . "	1·80	28·8	59·3	11·9
Jamadoba (XVIII) . . . "	1·70	28·10	56·80	15·10
Jharia, Raniganj series.				
Murilidih	2·2	29·30	57·00	43·2
Bhatdih	1·7	31·0	54·5	14·5
Huntodih (top)	2·07	32·2	52·75	15·05
N. Pipratanr	1·97	32·0	53·3	14·7
West Raniganj—Raniganj series.				
Nursamuda	6·1	33·3	52·1	14·6
Dadka	5·3	32·6	53·7	13·7
Ragnathbati	3·9	31·0	57·9	11·1
Dishergarh	2·57	33·95	54·95	11·1
Hatnal	2·15	31·05	48·9	20·05
Sanctoria	2·81	32·0	59·0	9·0
East Raniganj—Raniganj series.				
Ghusick	7·55	34·8	52·6	12·6
Nega	6·4	32·1	53·65	14·25
Searsole	7·5	31·1	52·3	16·6
Bowla	8·3	33·8	54·7	11·5
Joba	5·5	31·5	55·7	12·8
Samla	11·0	31·5	57·1	11·4
Koithi	4·7	33·2	53·7	13·1
Poniati	4·85	32·83	55·8	11·35
Poniati	6·0	30·7	59·9	9·4
Poniati	8·8	30·0	59·1	10·9
Taltore	6·3	29·6	65·0	15·4

N. B.—All analyses are of samples collected by officers of the Coal Grading Board. Analyses made at Government Test House, Alipur, Calcutta.

[1] Results given above are on a moisture-free basis. All the Jharia coals coke. Seams XII to XVIII give a hard coke. The Raniganj seams are generally non-coking, except Dishergarh and Sanctoria.

It must be mentioned, however, that entirely new areas are being opened—two in particular are producing coal. These are (1) the Chirmiri coalfield in Korea State, and (2) the Tandur coalfield in the Nizam's dominions (Hyderabad). During the five years 1924-1928, at least three new coalfields were opened and have been producing coal. These are (1) the Karanpura coalfield in the Damuda valley of Bihar, (2) the Talchir coalfield in the valley of the Brahmani in Orissa, and (3) the Wun coalfield of Yeotmal in the Wardha valley. In two areas the collieries have closed down; these are (1) the Mohpani and (2) Shahpur coalfields in the Satpura region of the Central Provinces.

The Gondwana system in the Indian Peninsula comprises the following formations :—

	Lr. Cretaceous	Umia plant beds.		Upper Gondwanas.
Jurassic	Up. Jurassic	Jabalpur stage.		
	Mid. Jurassic	Kota (Chaugan) stage.		
	Lr. Jurassic	Rajmahal (inter-trappean) plant beds.		
Trias	Parsora stage.			
	Maleri stage.			
	Maitur stage.	Panchet series		Lower Gondwanas.
Permian	Up. Permian	Raniganj series.	Damuda group.	
	Mid. Permian	Ironstone shales.		
	Lr. Permian	Barakar series with Karharbari stage and Umaria marine beds.		
	Up. Carboniferous	Talchir series with glacial boulder bed.		

The coal measures in most of the Gondwana coalfields are restricted to the Barakar series with its basal Karharbari stage. In the Raniganj and Jharia coalfields, however, there are valuable seams in the Raniganj series, in fact these constitute the most important coal measures in the Raniganj coalfield.

The output of the Gondwana coalfields is shown separately for each field in Table 29; *see* also figure 8 on page 67.

The Tertiary coalfields.

In Assam, the coal measures are of Tertiary (probably all of Eocene) age. The seams are interbedded between shales and sandstones. Unlike the Gondwana strata, which are locally faulted and buckled, the Assam coal seams and associated rocks have been somewhat severely folded. Fossil remains are not common and, when found, are usually poorly preserved. When identifiable leaves and plant remains are obtained, they are oecognised as parts of terrestrial

vegetation. On the other hand, the fauna is usually of invertebrate marine forms. It is generally agreed that the coal measure series

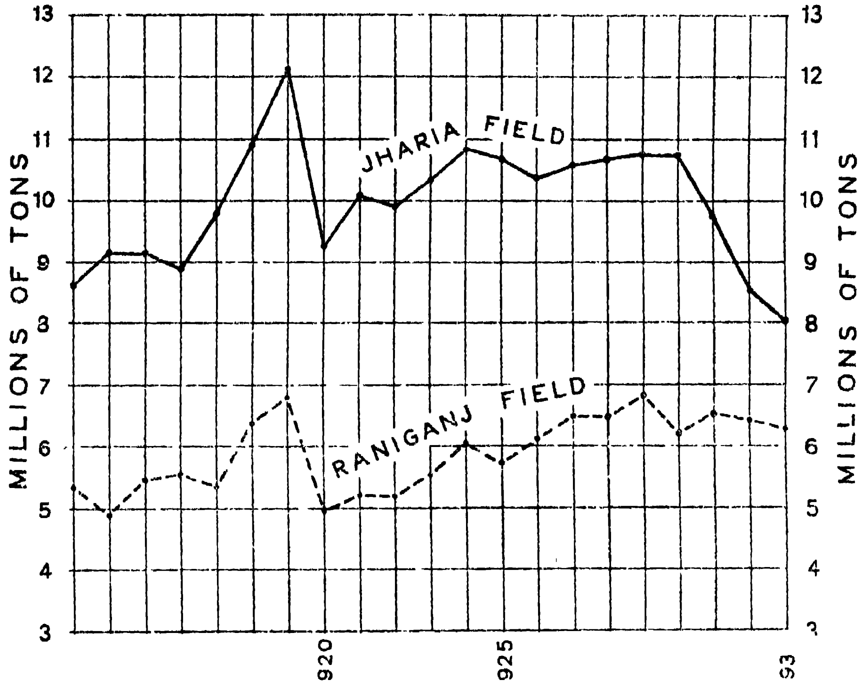

FIG. 8.—*Production of coal in the Raniganj and Jharia fields, 1913-1933.*

of Assam was deposited in the shallow waters of a sea—probably at the head of a gulf. This is also true of the equivalent strata, the Pegus of Burma, in certain horizons of which coal seams also occur.

Perhaps the most interesting feature of the coal measure series of Assam and the Pegus of Burma is the intimate association of petroleum with the coal. In Assam, the intimate connection of the coal and petroleum occurrences is too obvious to escape attention. Closer observation has shown that where coal is abundant in these coal measures petroleum is scarce and *vice versâ.* Sir Edwin Pascoe[1] says :—

'In Assam......in nearly every separate oil area, coal seams are found among the oil sands themselves, but it is especially in the horizons higher up that coal in any bulk is found........ Not only is there this vertical relationship, but

[1] *Mem. Geol. Surv. Ind.*, XL, Pt. 2, p. 322, (1914).

TABLE 29.—*Output of Gondwana coalfields for the years 1924 to 1933.*

—	1924 Tons.	1924 *Per cent. of Indian total.*	1925 Tons.	1925 *Per cent. of Indian total.*	1926 Tons.	1926 *Per cent. of Indian total.*	1927 Tons.	1927 *Per cent. of Indian total.*	1928 Tons.	1928 *Per cent. of Indian total.*
Bengal, Bihar and Orissa—										
Bokaro . .	1,343,500	*6·34*	1,494,966	*7·15*	1,514,918	*7·21*	1,790,594	*8·11*	2,026,791	*8·99*
Daltonganj . .	4,691	*0·02*	17,274	*0·08*	9,757	*0·05*	..	..	929	*0·01*
Giridih . .	768,690	*3·63*	786,642	*3·76*	818,681	*3·90*	855,253	*3·87*	804,118	*3·57*
Hutar . . .	..	..	..	..	..	..	709	..	205	..
Jainti . . .	78,547	*0·38*	76,680	*0·37*	82,604	*0·39*	56,724	*0·26*	48,059	*0·21*
Jharia . .	10,845,642	*51·22*	10,676,883	*51·08*	10,373,736	*49·40*	10,583,487	*47·93*	10,665,479	*47·31*
Karanpura . .	..	..	13,354	*0·07*	123,867	*0·59*	262,014	*1·19*	390,493	*1·73*
Rajmahal Hills .	..	..	1,653	*0·01*	1,788	*0·01*	1.488	*0·01*	636	..
Ramgarh . .	5,905	*0·03*	2,548	*0·01*	585	..	340	..	386	..
Rampur (Raigarh-Hingir).	49,445	*0·23*	45,410	*0·22*	29,272	*0·14*	26,895	*0·12*	31,623	*0·14*
Raniganj . .	6,035,347	*28·51*	5,729,686	*27·42*	6,124,884	*29·17*	6,472,036	*29·31*	6,460,490	*28·66*
Talchir . .	5,417	*0·03*	7,265	*0·04*	13,371	*0·07*	23,316	*0·10*	38,237	*0·17*
Central India—										
Sohagpur . .	131,174	*0·62*	116,170	*0·55*	108,599	*0·52*	82,541	*0·37*	117,423	*0·52*
Umaria . .	104,124	*0·49*	102,936	*0·49*	108,109	*0·51*	135,120	*0·61*	101,327	*0·45*
Central Provinces—										
Ballarpur . .	127,545	*0·60*	150,490	*0·72*	142,935	*0·68*	158,617	*0·72*	175,872	*0·78*
Hoshangabad .	3	..	..	..	..	..	..	..	..	..
Mohpani . .	76,526	*0·36*	70,039	*0·34*	71,482	*0·34*	..	..	..	..
Pench Valley .	473,896	*2·24*	485,768	*2·30*	416,708	*1·98*	505,913	*2·29*	556,481	*2·47*
Shahpur . .	1,111	..	1,119	*0·01*	423	..	6	..	..	..
Yeotmal . .	..	..	1,138	*0·01*	3,704	*0·02*	2,222	*0·01*	..	..
Hyderabad—										
Sasti .	25,050	*0·12*	38,153	*0·18*	28,034	*0·14*	25,477	*0·12*	35,615	*0·16*
Singareni . .	619,725	*2·93*	629,724	*3·01*	609,745	*2·90*	681,736	*3·09*	699,150	*3·10*
TOTAL. (Gondwana beds).	**20,696,338**	*97·75*	**20,447,898**	*97·82*	**20,583,202**	*98·02*	**21,664,488**	*98·11*	**22,153,314**	*98·27*

TABLE 29.—*Output of Gondwana coalfields for the years 1924 to 1933*—concld.

—	1929 Tons.	1929 *Per cent. of Indian total.*	1930 Tons.	1930 *Per cent. of Indian total.*	1931 Tons.	1931 *Per cent. of Indian total.*	1932 Tons.	1932 *Per cent. of Indian total.*	1933 Tons.	1933 *Per cent. of Indian total.*
Bengal, Bihar and Orissa—										
Bokaro	2,118,703	*9·05*	2,160,249	*9·07*	1,656,597	*7·63*	1,348,973	*6·69*	1,304,864	*6·60*
Daltonganj	1,522	*0·01*	1,569	*0·01*	411	..	..	..	..	..
Giridih	771,165	*3·29*	613,533	*2·58*	713,133	*3·28*	583,243	*2·90*	635,924	*3·21*
Hutar	357	..	195	..	..	..	..	..	..	..
Jainti	40,732	*0·17*	43,580	*0·18*	50,178	*0·23*	43,163	*0·21*	43,530	*0·22*
Jharia	10,785,745	*46·05*	10,753,858	*45·18*	9,755,037	*44·92*	8,551,283	*42·43*	8,014,949	*40·50*
Karanpura	467,127	*1·99*	482,141	*2·02*	461,678	*2·13*	409,566	*2·03*	343,876	*1·74*
Rajmahal Hills	565	..	445	..	1,699	*0·01*	1,500	*0·01*	1,752	*0·01*
Rampur (Raigarh-Hingir).	36,774	*0·16*	37,719	*0·16*	31,220	*0·14*	19,493	*0·10*	22,036	*0·11*
Raniganj	6,828,053	*29·16*	7,218,691	*30·33*	6,530,713	*30·07*	6,419,007	*31·85*	6,265,703	*31·66*
Talchir	47,505	*0·20*	68,973	*0·29*	142,312	*0·66*	253,586	*1·26*	316,539	*1·60*
Central India—										
Sohagpur	92,508	*0·39*	93,088	*0·39*	143,607	*0·66*	166,195	*0·52*	172,390	*0·87*
Umaria	112,624	*0·48*	100,145	*0·42*	83,321	*0·38*	74,293	*0·37*	80,378	*0·41*
Central Provinces—										
Ballarpur	202,061	*0·86*	211,980	*0·89*	223,025	*1·03*	217,421	*1·08*	256,344	*1·29*
Korea	..	..	3,517	*0·01*	31,351	*0·14*	113,858	*0·56*	264,257	*1·34*
Pench Valley	680,270	*2·90*	740,391	*3·11*	750,015	*3·45*	831,817	*4·13*	978,179	*4·94*
Raigarh State	..	..	..	..	..	..	..	..	2,131	*0·01*
Hyderabad—										
Sasti	47,455	*0·23*	46,808	*0·20*	53,417	*0·25*	61,184	*0·30*	49,794	*0·25*
Singareni	768,420	*3·28*	765,490	*3·22*	657,628	*3·03*	593,466	*2·95*	519,443	*2·63*
Tandur	..	..	..	..	46,530	*0·21*	126,471	*0·63*	184,165	*0·93*
TOTAL. (Gondwana beds).	**23,001,586**	*98·22*	**23,342,372**	*98·06*	**21,331,872**	*98·22*	**19,814,524**	*98·32*	**19,456,254**	*98·32*

there is another accompanying it of a geographical nature, according to which coal seams show a preference for the margins of the gulf in which the Tertiary sediments accumulated, while petroleum is usually found a little further from the coast.'

In north-west India, in Baluchistan, the Punjab Salt Range and Jammu (Kashmir), workable coal occurs in the Lower Eocene.[1] The seams are intercalated between pyritiferous shales and sandstones, with limestone in association. Identifiable plant remains are scarce, but the carbonised, woody parts of plants are occasionally met with in the coal. The strata above and below, and sometimes the shaley coal itself, is full of invertebrate animal remains—chiefly foraminifera—all marine types. Judging by the plant remains in the lignite of Bikaner (Palana) in Rajputana, which is on exactly the same horizon (Lower Eocene) as the Salt Range and other coals in this region, and which were evidently accumulated in the same marine region as these black and brown Eocene coals, it appears that the vegetable matter is the debris of terrestrial plants.

The Palana lignite is characterised by the large amount of fossil resin contained in it. The coals of Baluchistan and the Salt Range also contain small amounts of resin. This is also true of the Tertiary coals of Assam. The strata in the several areas of the north-west have suffered different degrees of tectonic disturbance. The lignite beds of Rajputana barely suffered any movement at all, the Tertiary rocks of Baluchistan are folded, while the coal-bearing beds in Jammu have been involved in the orogenic movements which culminated in the uplift of the Himalaya. It is significant in this connection that the vegetable matter in the Tertiary rocks of Rajputana has only been converted into lignite while the coals of Jammu (Kalakot) are distinctly anthracitic.

The following analyses of Upper Assam coals of Tertiary age will give a tolerably clear idea of their character.

The mean of two assays of Makum coal made in 1922 in the Laboratory of the Geological Survey of India was as follows :—

Fixed carbon	53·2 per cent.
Volatile matter	44·0 ,, ,,
Moisture	1·2 ,, ,,
Ash	1·6 ,, ,,

[1] 'General Report for the year 1934', *Rec. Geol. Surv. Ind.*, LXIX, Pt. 1, pp. 65, 71, (1935).

Makum coal is largely used by the railways in Assam, by the river steamers navigating the Brahmaputra river and by a large number of tea gardens in the province. Considerable quantities are also often exported to Bengal.

The average composition given by three samples from the Upper Ledo colliery representing an aggregate thickness of 49 feet, and by five samples from the Tikak colliery representing an aggregate thickness of 47 feet, is shown below :—

	Upper Ledo. Per cent.	Tikak. Per cent.
Fixed carbon	55·59	58·99
Volatile matter	40·15	37·25
Moisture	1·80	2·09
Ash	2·46	1·67
TOTAL	100·00	100·00

Assays of Coal from the Jaipur and Nazira coalfields.

—	Fixed carbon.	Volatile matter.	Moisture.	Ash.
	Per cent.	Per cent.	Per cent.	Per cent.
Jaipur field—				
Highest	53·71	45·10	10·31	18·18
Lowest	41·38	35·49	3·95	1·10
Average of 25 assays	48·78	39·80	6·42	4·82
Nazira field—				
Highest	54·64	42·90	7·23	14·45
Lowest	45·49	34·36	3·89	2·22
Average of 12 assays	50·04	38·11	5·49	6·36

Coal of excellent quality also occurs in the Namchik valley, a tributary on the left bank of the Dihing river, three days' journey above Margherita. The locality, which although only 18 miles in a straight line from Ledo is difficult of access, was examined by Sir Edwin Pascoe in 1911 and has since been carefully studied by geologists of the Burmah Oil Company, Ltd., and others. Five groups of seams were noticed, with a total thickness of about 60 feet of coal.

TABLE 30.—*Production of Tertiary coal during the years 1924 to 1933.*

—	1924		1925		1926		1927		1928	
	Tons.	*Per cent. of Indian total.*	Tons.	*Per cent. of Indian total.*	Tons.	*Per cent. of Indian total.*	Tons.	*Per cent. of Indian total.*	Tons.	*Per cent. of Indian total.*
Assam—										
Khasi and Jaintia Hills	280		845		555		825		588	
Makum	274,479	*1·58*	262,959	*1·52*	255,189	*1·43*	271,220	*1·46*	238,926	*1·32*
Naga Hills	60,083		55,038		45,317		51,297		58,575	
Sibsagar	..		..		..		..		..	
Baluchistan—										
Khost	25,678	*0·19*	17,085	*0·17*	3,545	*0·07*	1,734	*0·07*	2,542	*0·08*
Sor Range, Kalat, Mach.	14,879		17,712		12,041		12,710		15,389	
Burma—										
Kamapying (Mergui)	255	*0·00*	..	..	..	..	..	..	..	..
Southern Shan States	..	..	25	*0·00*	..	..	..	..	..	..
Kalewa (Upper Chindwin)	..	..	..	..	..	..	..	..	..	..
Namma (Northern Shan States).	..	..	..	..	..	..	..	..	..	..
North-West Frontier Province—										
Hazara	..	..	..	..	..	..	..	..	..	..
Punjab—										
Jhelum (Dandot)	52,942		49,369		46,961		39,545		24,674	
Mianwali	18,787	*0·38*	18,341	*0·36*	15,644	*0·33*	15,488	*0·28*	18,161	*0·21*
Shahpur	8,693		6,952		5,438		7,671		3,317	
Rajputana—										
Bikaner	21,870	*0·10*	28,153	*0·13*	31,275	*0·15*	17,358	*0·08*	27,386	*0·12*
TOTAL (Tertiary beds)	**477,946**	*2·25*	**456,479**	*2·18*	**415,965**	*1·98*	**417,848**	*1·89*	**389,558**	*1·73*

TABLE 30.—*Production of Tertiary coal during the years 1924 to 1933*—concld.

—	1929 Tons.	1929 Per cent. of Indian total.	1930 Tons.	1930 Per cent. of Indian total.	1931 Tons.	1931 Per cent. of Indian total.	1932 Tons.	1932 Per cent. of Indian total.	1933 Tons.	1933 Per cent. of Indian total.
Assam—										
Khasi and Jaintia Hills	970		1,005		743		1,233		2,118	
Makum	262,987	*1·38*	307,414	*1·51*	239,315	*1·27*	170,399	*1·04*	164,412	*0·98*
Naga Hills	58,558		50,621		34,963		38,403		27,624	
Baluchistan—										
Khost	3,163	*0·07*	3,355	*0·07*	3,821	*0·08*	5,297	*0·10*	4,376	*0·06*
Sor Range, Kalat, Mach	13,059		12,539		12,733		13,631		7,086	
Punjab—										
Jhelum	20,506		26,904		27,386		32,527		41,062	
Mianwali	19,064	*0·18*	20,011	*0·21*	22,831	*0·25*	30,792	*0·36*	45,581	*0·47*
Shahpur	3,566		3,704		4,623		9,538		7,456	
Rajputana—										
Bikaner	35,275	*0·15*	35,123	*0·15*	38,148	*0·18*	37,043	*0·18*	33,194	*0·17*
TOTAL (Tertiary beds)	**417,148**	*1·78*	**460,676**	*1·94*	**384,563**	*1·78*	**338,863**	*1·68*	**332,909**	*1·68*

Further proximate analyses of these Tertiary coals are given below :—

Tertiary Coals.

—	Moisture.	Volatile matter.	Fixed carbon.	Ash.
Assam (Eocene).	Per cent.	Per cent.	Per cent.	Per cent.
Borjan (resinous) . .	3·6	55·78	39·3	1·32 C.
Borjan (brights) . . .	4·35	48·00	45·7	1·95 C.
Wakching	8·15	38·48	52·98	0·39
Namdang	2·04	42·27	54·48	1·21 C.
Rajputana (Lr. Eocene).				
Palana resin . . .	0·65	99·09	0·06	0·2
Light lignite . . .	5·13	71·45	11·57	11·85 C.
Dark lignite . . .	12·55	46·67	36·38	4·40
Wet lignite	45·6	25·13	24·92	4·35
Dry lignite	8·5	41·8	40·8	9·5
Baluchistan (Lr. Eocene).				
Mach	10·71	41·43	45·68	2·18 C.
Mach	10·9	33·1	41·0	15·0
Digari	7·7	43·3	44·7	4·3
Khost	2·29	41·51	46·52	9·68 C.
Sharig	6·8	40·8	47·6	4·8
Salt Range, Punjab (Lr. Eocene).				
Dandot	5·87	43·65	38·04	12·44 C.
Dandot	6·13	36·81	47·17	9·89
Barochi	10·87	38·71	42·81	5·04
Makerwal	2·40	43·54	41·38	12·68 C.

C=Strongly coking coals.

Tertiary Coals—concld.

—	Moisture.	Volatile matter.	Fixed carbon.	Ash.
Jammu, Kashmir (Lr. Eocene).	Per cent.	Per cent.	Per cent.	Per cent.
Kalakot—7-foot seam, lower measures.	0·63	12·45	78·12	9·0 C.
Kalakot—16-foot seam, upper measures.	4·62	14·54	69·44	11·4
Sair—upper seam, upper measures.	8·43	20·93	60·16	10·48
Sair—upper seam, upper measures.	8·04	25·00	60·54	6·42

C=Strongly coking coals.

N.B.—All the above analyses are of picked specimens and not samples. These analyses have been compiled from various sources. Many were made in the Geological Survey Laboratory, Calcutta, by Mahadeo Ram.

Industrial Considerations.

Export trade.

The exports of Indian coal (beginning seriously from 1900) up to 1914 averaged less than a million tons. The highest pre-war figure was a little over a million tons in 1906. During the war these exports fell, due to shortage of shipping. In 1918, the exports were less than 75,000 tons, but rose rapidly to over 1,200,000 tons in 1920, when export restrictions were imposed to relieve the strain on the railways. A rationing scheme was drawn up and, at the time, had the entire approval of the commercial community. Later, however, the working of the scheme gave rise to doubts and the difficulties of the situation were enhanced by poor raising in the coalfields—4·5 million tons less in 1920 than the output of 1919. In April, 1922, all restrictions were removed on the export of cargo or bunker coal by sea to customs ports in India. The embargo was entirely removed from January 1st, 1923.

The embargo resulted in the temporary disappearance of Indian coal from overseas markets. Some recovery was made in the five years 1924-28, and the present quinquennial period 1929-33 opened with an attractive export trade to Penang, Singapore, Colombo, Sabang and Aden, but these have since fallen and in some cases have disappeared. It must be mentioned that none of these ports import any large quantities of coal for industrial purposes; also, in most

of these markets Indian coal had not, in 1924, earned a reputation for good quality—due to carelessness in grading. Japanese coal and coal from Sumatra and South Africa, although known to be of no better quality than good Indian coal, were in considerable demand. Under these circumstances, an Indian Coal Committee was set up in 1924 and had altered the situation completely by 1929 but since then the trade has fallen into a depression [for particulars of the work of the Coal Grading Board see *Records, Geological Survey of India*, Vol. LXIV, pp. 64-67, (1930)].

TABLE 31.—*The approximate quantity of Coal despatched to various ports during 1933.*

—	No. of ships carrying cargoes.	Quantity. Tons.
Akyab	8	10,960
Basin	2	4,672
Bhavnagar	13	32,237
Bombay	79	414,218
Cannanore	1	2,082
Chandbali	5	304
Chittagong	23	28,269
Cochin	5	14,943
Colombo	50	233,686
Cuddalore	8	43,533
Feroke	1	7,824
Hongkong	21	117,011
Karachi	19	59,578
Madras	25	131,924
Mandapam	7	56,696
Manila	1	6,242
Marmagoa	8	37,054
Mauritius	1	922
Negapattam	1	3,012
Navalakhi	5	14,464
Porbunder	8	28,954
Port Blair	4	3,252
Port Kundla	1	1,942
Port Okha	7	41,556
Rangoon	85	454,659
Singapore	3	13,367
Tuticorin	12	52,495
Verawal	4	14,093
Whampa	2	6,627
Akyab and Rangoon	1	6,716
Colombo and Madras	1	5,997
Hongkong and Whampa	5	32,176
Bombay and Karachi	2	4,040
Bombay, Karachi and Marmagoa	1	10,650
TOTAL	419	1,896,155

Hard coke.

The quantity of hard coke manufactured in India during the quinquennium under review is shown in Table 32. It will be seen that by far the larger proportion of this coke is made from Jharia coal and that the recovery of coké averages from 74 to 75 per cent. of the coal used.

TABLE 32.—*Quantity of Hard Coke produced in India during the years 1929 to 1933.*

—	1929.	1930.	1931.	1932.	1933.
	Tons.	Tons.	Tons.	Tons.	Tons.
Tata Iron and Steel Company, Ltd.	733,812	671,062	600,752	688,574	706,113
Indian Iron and Steel Company, Ltd.	368,956	388,717	240,568	216,605	212,302
Bengal Iron Company, Ltd. .	234,613	172,946	56,022	82,965	80,548
Burrakar Coal Company, Ltd. .	97,228	99,036	99,438	60,674	93,324
Lodna Colliery Company, Ltd.	91,173	89,551	79,083	58,025	37,627
Bararee Coke Company, Ltd. .	76,134	77,252	68,342	53,087	52,734
Eastern Coal Company, Ltd. .	41,956	41,122	40,483	29,395	23,900
Giridih (E. I. Railway colliery)	43,335	31,636	25,620	24,930	20,552
Assam Railway and Trading Company, Ltd.	930	790	685	517	556
TOTAL COKE MANUFACTURED	**1,688,137**	**1,572,112**	**1,309,993**	**(a)1,214,772**	**1,227,746**
Coal used	2,239,284	2,093,043	1,757,904	1,638,665	1,658,095
Percentage recovery . .	*75 30*	*75·11*	*74 52*	*74·13*	*74 04*
Sources of coal used— Jharia field . . .	2,154,185	1,995,344	1,687,681	1,585,733	1,517,483
Giridih field . . .	53,553	51,035	33,209	32,724	27,245
Bokaro field . . .	28,756	44,204	21,128	4,637	..
Raniganj field . . .	..	..	12,456	12,878	110,469
Lakhimpur (Namdang) field	2,790	2,370	3,435	2,693	2,808
TOTAL .	**2,239,284**	**2,093,043**	**1,757,904**	**1,638,665**	**1,658,095**
Coal used for coking by— Three iron and steel companies	1,772,916	1,637,900	1,341,055	1,322,969	1,343,151
Others	466,308	455,143	410,849	315,696	314,944

(a) Excluding 271 tons produced from the Jarangdih colliery.

Soft coke.

Although the present production of soft coke in India does not exceed some 800,000 tons annually and is almost entirely used in the larger towns of Bengal and Bihar, there are attractive features in this trade. The production of soft coke during the years 1924 to 1933 is shown in Table 33. Soft coke manufacture has been described in 'Capital' (July 5th and 12th, 1928). It is there shown that only the

relatively inferior grades of coal are used for this purpose and that probably 100 tons of raw coal produce 50 tons of soft coke. When it is realized that the population of India is of the order of 300 millions and that barely 2 million tons of coal (raw coal and soft coke) are used as domestic fuel, it is apparent that there are possibilities of great expansion in the household coal trade. With a view to assist this branch of the coal industry, the following Act of the Indian Legislature received the assent of the Governor-General on the 1st October, 1929 :—

Act No. VIII of 1929.—*An Act to provide for the levy of a cess on soft coke despatched by rail from collieries in the provinces of Bengal and Bihar and Orissa.*

1. (1) This Act may be called the Indian Soft Coke Cess Act, 1929..........
2. (*c*) 'Soft-coke' means all coke which is unsuitable for metallurgical purposes.
3. (1) There shall be levied and collected on all soft coke despatched by rail from collieries in the provinces of Bengal and Bihar and Orissa a cess at the rate of two annas per ton.

TABLE 33.—*Production of Soft Coke in India during the years 1924 to 1933.*

(Statute tons).

Field.	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933
Bengal—										
Raniganj . .	7,521	7,471	7,941	11,596	18,736	17,498	13,491	16,875	18,904	18,414
Bihar and Orissa—										
Sontal Parganas .	(*a*) 3	(*b*) 164	(*a*) 515	..	..	..	..	..	(*a*) 46	(*a*) 10
Raniganj (*c*) .	115,442	113,173	104,704	92,633	60,186	42,036	42,489	26,764	17,908	18,148
Jharia . . .	176,797	290,807	397,589	500,812	606,520	693,186	688,250	676,976	719,980	784,429
Bokaro . .	4,882	4,328	4,916	3,571	3,560	4,407	5,391	3,544	3,390	3,164
Giridih . .	..	26	..	..	..	..	..	..	..	..
Karanpura .	..	..	..	..	..	..	..	17	..	..
Central Provinces—										
Pench Valley .	100	..	..	..	..	..	..	..	..	..
TOTAL .	**304,745**	**415,969**	**515,665**	**608,612**	**689,002**	**757,727**	**749,621**	**724,176**	**760,228**	**824,165**

(*a*) Raniganj coalfield.
(*b*) Rajmahal (Damin-i-ko) coalfield.
(*c*) Manbhum district only.

5. The proceeds of the cess and any other monies received by the Committee shall be applied to meeting the expenses of the Committee and the cost of such measures as it may consider advisable to take for promoting the sale and improving the methods of manufacture of soft coke.

A report on the available reserves of coal in India has been recently published[1] in which it is estimated that the reserves of good-quality coal in India at the end of 1932 amounted to about 4,500 (4,521) million tons, made up of some 1,700 (1,694) million tons of coking coal and some 2,800 (2,827) million tons of non-coking coal.

Reserves of coal.

In the following Tables, 34 to 37, are shown: (1) the number of persons employed in the Indian coal-mining industry during the period 1929 to 1933; (2) the comparison of death rate from accidents at coal mines in British India with those in Indian States during the years 1929 to 1933; (3) the production of coal compared with deaths from coal-mining accidents in India during the years 1929 to 1933; and (4), for comparison, the death rate from coal-mining accidents in Great Britain.

Labour.

Although the efficiency of the Indian coal miner is relatively low compared with that of the collier in most countries, yet the cost of getting the coal is also low. The question of increasing the efficiency by the introduction of machine mining has received careful consideration from most of the larger colliery companies, and there seems to be little doubt that with increased demands for coal such modern methods of coal cutting will be employed to a greater extent than is now possible.

It will be remembered that the Indian Mines Act, 1923, received the assent of the Governor General on the 23rd February, 1923, and the Government of India took advantage of its enactment to revise the regulations relating to the safety of mines and persons engaged in mining. The new regulations came into force on the 1st July, 1924. Since then 'The Indian Coal Mines Regulations', 1926, made under Section 29 of the Indian Mines Act, 1923, has been published in Notification No. M-1055 (1), dated 7th September, 1926, of the Government of India, in the Department of Industries and Labour, and amended in Notification No. M-1055 (1), dated

[1] L. L. Fermor, 'India's Coal Resources', Bulletins of Indian Industries and Labour, No. 54, pp. 1-14, (1935); see also *Rec. Geol. Surv. Ind.*, LXIX, Pt. 3, (1935).

13th May, 1929. 'Regulations for prohibiting the employment of Women underground in Mines' has been published in Notification No. M-1055, dated 7th March, 1929, of the Government of India, in the Department of Industries and Labour.

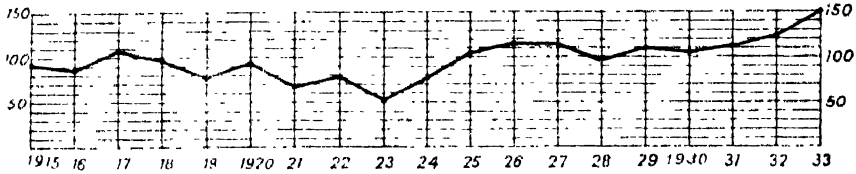

Fig. 9. *Production of coal in thousands of tons per life lost by coal-mining accidents.*

Coal-dust.

The protection of mines from the dangers of coal-dust was carefully investigated by a special committee appointed by the Government of India, 1923 (Department of Industries and Labour, Resolution No. M-498, dated 24th July, 1923). This committee submitted a second report in 1929 in which they state that—

(1) 'The dust of any coal seam of commercial value in India, if in a sufficiently fine state of division and in sufficient quantity, is capable of rendering an atmosphere of ordinary air explosive.......'

(2) 'The dust from a seam having a large percentage of ash and a low percentage of volatile matter is less readily ignitable than dust from a seam low in ash and high in volatiles.......'

(3) '......A correctly proportioned, properly placed and properly tamped charge of any explosive is unlikely to ignite coal-dust.......'

(4) 'The removal of all fine coal-dust within a comparatively small radius of a charge of explosive before the shot is fired will practically eliminate the risk of an explosion.'

(5) 'It is extremely improbable that an explosion of coal-dust will arise from a charge of permitted explosive which has passed the prescribed tests in Great Britain and which is used in compliance with the conditions attached to its use.'

Precise information relating to mining regulations, etc., has recently been published in a valuable handbook by Mr. R. R. Simpson, late Chief Inspector of Mines in India. This volume—'The Indian Mines Manual' (1929)—gives all the available information on recent legislation in regard to mines, mining leases, land acquisition, Indian Electricity Rules, Indian Explosives Act, Workmen's Compensation Act (1923), Indian Boilers Act (1923), the Bengal Mining Settlements Act (1923) and the Bihar and Orissa Mining Settlements Act (1920).

TABLE 34.—*Number of persons employed in the Indian Coal-Mining Industry during the years 1924 to 1933.*

—	1924.	1925.	1926.	1927.	1928.	*Average.*	Per cent. of average total.	1929.	1930.	1931.	1932.	1933.	*Average.*	Per cent. of average total.
Assam . . .	4,464	4,199	4,523	4,034	4,216	*4,287*	2·28	4,145	4,401	3,533	2,275	1,978	*3,266*	1·86
Baluchistan . . .	1,108	951	232	323	254	*574*	0·30	278	281	261	264	275	*272*	0·15
Bengal . . .	43,621	42,781	43,498	44,274	43,855	*43,606*	23·21	44,303	46,592	44,642	43,423	43,651	*44,522*	25·71
Bihar and Orissa . .	128,523	114,934	112,945	109,196	108,546	*114,829*	61·11	109,082	110,363	102,115	95,082	88,571	*101,043*	58·35
Burma . . .	23	19	..	..	..	*8*	..	..	..	..	..	..	..	..
Central India . .	3,157	2,759	2,497	3,259	3,144	*2,963*	1·58	2,617	1,915	1,851	2,108	2,133	*2,125*	1·23
Central Provinces . .	8,125	9,174	8,366	6,553	6,923	*7,828*	4·17	7,656	7,972	9,138	10,221	13,890	*9,775*	5·64
Hyderabad . . .	13,590	12,701	12,134	11,464	11,816	*12,341*	6·57	10,651	11,751	10,501	10,753	11,046	*10,940*	6·32
Punjab . . .	1,575	1,579	1,388	1,260	766	*1,314*	0·70	743	964	985	1,315	1,516	*1,105*	0·65
Rajputana . .	120	165	166	169	167	*157*	0·08	132	131	149	126	113	*130*	0·07
TOTAL	204,306	189,262	185,749	180,532	179,687	*187,907*	100·00	179,607	184,370	173,175	165,567	163,173	*173,178*	100·00

TABLE 35.—*Comparison of death-rate from accidents at Coal Mines in British India with those of Indian States during 1924 to 1933.*

YEAR.	AVERAGE NUMBER OF PERSONS EMPLOYED DAILY.		DEATHS FROM ACCIDENTS.		DEATH-RATE PER 1,000 PERSONS EMPLOYED.	
	British India.	*Indian States.*	British India.	*Indian States.*	British India.	*Indian States.*
1924 . .	186,929	*17,377*	230	*44*	1·23	*2·53*
1925 . .	173,132	*16,130*	186	*16*	1·07	*0·99*
1926 . .	170,620	*15,129*	171	*13*	1·00	*0·86*
1927 . .	165,266	*15,266*	181	*15*	1·09	*0·98*
1928 . .	164,154	*15,533*	218	*16*	1·32	*1·03*
Average .	*172,020*	*15,887*	*197*	*21*	*1·14*	*1·28*
1929 . .	165,697	*13,910*	194	*18*	1·16	*1·29*
1930 . .	169,035	*15,335*	211	*16*	1·25	*1·04*
1931 . .	158,267	*14,908*	185	*11*	1·17	*0·76*
1932 . .	148,555	*17,012*	151	*13*	1·02	*0·76*
1933 . .	144,764	*18,409*	124	*8*	0·86	*0·43*
Average .	*157,263*	*15,915*	*173*	*13*	*1·09*	*0·86*

TABLE 36.—*Production of coal compared with deaths from coal-mining accidents in India.*

—	1924.	1925.	1926.	1927.	1928.	*Average.*	1929.	1930.	1931.	1932.	1933.	*Average.*
Deaths from coal-mining accidents.	274	202	184	196	234	*218*	212	227	196	164	132	*186*
Thousands of tons of coal raised for each life lost.	77	103	114	113	96	*101*	110	105	111	123	150	*120*
Lives lost per million tons of coal raised.	13·0	9·6	8·8	8·9	10·4	*10·1*	9·1	9·5	9·0	8·1	6·7	*8·5*
Death-rate per thousand persons employed.	1·34	1·07	0·99	1·09	1·30	*1·16*	1·24	1·23	1·13	0 99	0·81	*1·08*

TABLE 37.—*Death-rate from coal-mining accidents in the United Kingdom.*

—	1924.	1925.	(*a*) 1926.	1927.	1928.	1929.	1930.	1931.	1932.
Number of persons employed	1,230,248	1,117,828	1,041,632	1,037,391	951,632	969,736	943,442	877,141	827,439
Number of deaths . .	1,201	1,136	649	1,128	989	1,076	1,013	859	881
Death-rate per 1,000 persons employed.	0·98	1·02	(*b*) 0·62	1·09	1·04	1·11	1·07	0·98	1·06
Deaths per 1,000,000 tons of coal raised.	4·36	4·53	4·95	4·36	4·04	4·05	4·04	3·82	4·13

(*a*) In this year, work at coal mines was reduced by protracted disputes and the number of deaths from accidents was correspondingly affected.

(*b*) This figure would perhaps be more correctly estimated as 1·08.

Copper.

[L. L. FERMOR.]

Copper was formerly smelted in considerable quantities in Southern India, in Rajputana, and at various places along the outer Himalaya in which a persistent belt of killas-like rock is known to be copper-bearing in numerous places, as in Kulu, Garhwal, Nepal, Sikkim and Bhutan. In Chota Nagpur several attempts have been made to work lodes reputed to be rich in the metal. At Baragunda in the Giridih sub-division of Hazaribagh, a low-grade ore-body of about 14 feet in thickness was prospected by shafts to a depth of 330 feet, and an unsuccessful attempt was made many years ago to work the lode.

Singhbhum.

In the Singhbhum district of Bihar and Orissa a copper-bearing belt, marked out by old workings, persists for a distance of some 80 miles, stretching from Duarparam on the Bamini river in the Kera Estate, in an easterly direction through the Kharsawan and Seraikela States, into Dhalbhum, where the strike of the belt curves round to south-east, running through the Rajdoha and Matigara properties formerly belonging to the Cape Copper Company, to Bhairagora at the extreme south-eastern end.

The copper ores occur as rather indefinite lodes interbedded with the Dharwar phyllites and schists[1] or in crushed granites intrusive therein, the mineralisation being related, according to Dr. J. A. Dunn, to a zone of overthrust.[2] Sometimes the ore is collected into fairly well-defined bands, but very frequently it occurs in the form of grains so sparsely disseminated through a considerable thickness of schists as to be unworkable. When concentrated into definite lodes, as at Matigara or Mosaboni, the ore may be of high grade, and well worth working when it can be proved to exist in sufficient quantity to render it worth while to erect the plant necessary to handle large quantities of ore.

Rakha Mines, Matigara.

These copper-ores have been the subject of exploitation on European lines by various companies during the past fifty years, always until recently with disastrous results, in some cases due to the poor character of the deposit attacked and in others to the unwise expenditure of a limited

[1] *Rec. Geol. Surv. Ind.*, XXXVIII, p. 26, (1908); L. L. Fermor, *Proc. As. Soc. Beng.*, N. S., XV, p. clxxxviii, (1919).
[2] *Rec. Geol. Surv. Ind.*, LXVIII, p. 31, (1934).

capital on expensive plant before the deposit had been proved. Such results caused business and mining men to avoid the Singhbhum copper and consequently, in the absence of private enterprise, the Geological Survey of India, during the years 1906 to 1908, carried out a series of diamond-drilling operations on the belt. This directed attention to the problem, and the Cape Copper Company, after a further prospecting campaign, took over the Rajdoha Mining Company's rights at Matigara. The property known as Rakha Hills Mines was actively developed and, had it not been for the difficulty of procuring plant during the war, smelting furnaces would have been in operation before 1918.

At the end of August in 1918, the Company's ore reserves amounted to 407,000 short tons of an average assay value of 3·8 per cent. copper. An electric power house, a concentration plant and a blast furnace with sintering and converting plants had been erected, and a refinery was completed during the quinquennium 1919-23. The total production of copper-ore and metal from the Rakha mine during that five-year period amounted to 130,797 and 3,549·76 tons, respectively, valued at Rs. 18,08,141 and Rs. 41,58,154. In March, 1923 mining operations were stopped and the company's property was placed in the hands of receivers.

As seen at the outcrops, the Singhbhum lodes seem to be very poor where they have not been removed by the ancients. Typically they consist of a small thickness of vein quartz, associated with malachite, chrysocolla, and red oxides of iron containing a small quantity of copper, possibly as red oxide, with sometimes small encrustations of liebethenite. In depth, as seen in the diamond drill cores and the levels of the Matigara mine, the ores consist practically entirely of chalcopyrite,[1] but pyrite and pyrrhotite also occur and, as Dr. Dunn has shown recently,[2] the nickel-bearing sulphides, pentlandite (Fe, Ni) S, violarite $(NiFe)_3S_4$, and millerite (NiS). The other minerals noticed above are evidently the outcrop alteration product of the yellow sulphide. Judging from small specimens found on the dump-heaps of the old workings there must be a zone of chalcocite not very many feet below the surface, probably formed by secondary enrichment at the expense of the portions of the deposits denuded away, and of those now appearing as gossans of oxide ores. The primary chalcopyrite ores have probably

[1] *Rec. Geol. Surv. Ind.*, XXXVIII, p. 36, (1909).
[2] *Trans. Min. Geol. Inst. Ind.*, Vol. XXIX, pp. 168-172, (1934).

been deposited in their position as rather indefinite lodes following the bedding of the schists, after the arrival of the latter in their present position. The schists with which the copper lodes are associated are chiefly varieties of muscovite and chlorite-quartz-schists, with quartzite layers, and schists derived from granite intrusions and epidiorites. According to Dr. Dunn, the payable lodes are in the harder and more massive rocks in which the features are clearer and the mineralisation less dispersed, that is in the granite, epidiorite and quartzite.[1] Apatite and tourmaline are common minerals in the schists associated with lodes.

The information obtained in the borings put down by the Geological Survey is shown in Table 38. These results show that much of the ore of Singhbhum is of low grade, and just below what is likely to be payable except when working on very large quantities of ore. A thickness of 16·80 feet, averaging 2·65 per cent. of copper, found at Laukisra, shewed that the lode was worth further testing by private enterprise.

The characteristic and persistent band of chalcopyrite with quartz blebs intersected by the Matigara bore-hole at 306 feet, where it yielded 12·81 per cent. of copper, but was only 3 inches thick, and which was seen in the Matigara mine in the 228-foot level with a thickness ranging from 6 inches to 2 feet, was followed on the dip in the Gladstone Shaft and found to extend below the depth proved by boring.

TABLE 38.—*Results of diamond-drill boring on the Singhbhum copper lodes.*

No. of bore-hole.	Locality.	Total depth of hole.	Depth of lode or cupriferous zone.	Actual thickness of lode assayed.	Percentage of copper.
1	Kodomdiha	..	392′—404′	8 feet	5·10
2	Do.	1,093′	1,069′	1 foot	1·82
3	Galudih (Regadih)	430′	131′—294′	..	..
			293′	13 inches	0·61
4	Landup (Nadup)	465′	197′—198′	14 inches	3·33
5	Matigara	837′	693′—697′	3 feet 2 inches	2·00
			697′—701′ 8″	3 feet 8 inches	1·29
			733′ 5″—736′ 1″	2 feet 1 inch	1·01
			736′ 1″—736′ 5″	3 inches	12·81
			736′ 5″—739′	2 feet	0·42
6	Laukisra	392′	150′—168′	16 feet 10 inches	2·65
			169′—171′	1 foot 10 inches	2·13
			179′—184′	4 feet 8 inches	1·37

[1] *Ibid.*, p. 165.

In 1920 the Cordoba Copper Company, under the management of Messrs. John Taylor and Sons, commenced prospecting operations in the Mosaboni area, Singhbhum, on an option from the Cape Copper Company, and met with most promising results. After piercing a zone of secondary enrichment in which the predominant ores were malachite and cuprite, an impoverished zone made its appearance in which there was practically no ore, although the lode channel was well defined. Beyond the impoverished zone chalcopyrite began to make its appearance in the shape of small lenses of ore. At a vertical depth of 169 feet from the surface, tunnels driven along the lode proved solid chalcopyrite, in some places 2 feet wide, over a considerable distance in length, giving values of from 10 to 25 per cent. of copper. Up to February, 1924, twelve shafts had been sunk on this lode. Below the 169-foot horizon some promising ore ground carrying solid chalcopyrite was opened up.[1] In this year the option was exercised and the mining rights purchased from the Cape Copper Company.

Mosaboni Mines; Bihar and Orissa.

Another company, the North Anantapur Gold Mines, Limited, also managed by Messrs. John Taylor and Sons, commenced an investigation of the Sideshur-Kendadih copper area in Singhbhum in 1922. The area lies between the concessions of the Cape Copper Company and the Cordoba Copper Company. By the end of 1923 one shaft had reached 258 feet without intersecting the lode. The ore is a sulphide. This company also started exploiting copper in Kharsawan State, about eight miles north-west of Amda railway station, Bengal Nagpur Railway.

In 1924 the Cordoba Copper Company was reconstructed as the Indian Copper Corporation, Ltd., with a capital of £225,000, and acquired not only the properties of the Cordoba Copper Company, but also those of the North Anantapur Gold Mines, Ltd., lying immediately to the north, and a property in Kharsawan State prospected and owned by the Ooregum Gold Mining Company of India, Ltd.

Work was concentrated upon the Mosaboni area, and by the end of April, 1925, nearly 329,000 tons of 4·04 per cent ore had been developed. Operations were suspended during 1926 pending the raising of the capital required for the erection of the necessary concentrating, smelting, refinery and power plants. Early in 1927

[1] Information supplied by the Superintendent, Mr. B. Kitto.

the Anglo-Oriental and General Investment Trust, Ltd., London, assumed control, a sum of £350,000 was subscribed as debentures for the purpose and the erection of plant consisting of power plant, concentration mill, and smelter was commenced at the company's new site at Maubhandar, Ghatsila.

In July, 1930 a rolling mill for the production of yellow metal or brass sheet (62 per cent. of copper and 38 per cent. of zinc) was completed and the first yellow metal sheet ever made in India was produced. In 1931 the technical management of the Corporation was handed over to the New Consolidated Goldfields, Ltd., of South Africa, under whose management operations still continue. In 1932 further debentures for £125,000 supplied funds to permit an increase of plant and an increase of production by 50 per cent. This extension was completed in October, 1933 and the authorised capital of the Corporation now stands at £900,000. With the completion of this extension of plant the production capacity of the Corporation is 6,500 tons of refined copper and 8,000 tons of yellow metal sheet per annum.

The output of the Indian Copper Corporation, since production commenced, is as follows: -

Year.	Ore.	Refined Copper Ingots.	Yellow Metal Sheet.
	Tons.	Tons.	Tons.
1929	73,519	1,635	..
1930	119,787	2,974	718
1931	144,250	4,069	3,637
1932	165,977	4,443	5,440
1933	181,907	4,800	6,143
TOTALS .	685,440	17,921	15,938

Production of ore during development in previous years is shown in the previous Quinquennial Review[1]. The value of the ore is

[1] *Rec. Geol. Surv. Ind.*, LXIV, pp. 81, 82, (1930).

shown in Table 39, whilst the average prices at which the copper and yellow metal produced were sold in the Indian market are as follows :—

—	Refined copper.		Yellow metal.	
	Tons.	Rupees (per ton).	Tons.	Rupees (per ton).
1929	1,635	1,200	..	..
1930	2,157	..	712	..
1931	1,668	673	3,613	719
1932	1,312	689	4,830	657
1933	1,317	599	6,143	631

The successive stages in the treatment of the ore are briefly as follows. The ore is put through a primary concentrating plant at the mine head, crushed in two stages to pass a ½-inch screen and the crushed ore carried by belt conveyer and aerial ropeway a distance of six miles to the concentrating mill and smelter at Maubhandar. After fine grinding in ball mills the ore passes to the mineral separation or oil flotation plant, with ultimate production of dried concentrates assaying roughly 30 per cent. of copper, and containing approximately equal parts of copper, iron and sulphur. In the smelting plant the concentrates are treated successively in a mechanical roaster, Bessemer converters, and pulverised-coal-fired refining furnaces.

The refined copper known as 'B. S.' or Best Select Copper Ingots assays from 99·5 to 99·7 per cent. of copper and is marketed in ingot form in India, the sales averaging 1,200 to 1,500 tons per annum. Copper production in excess of this is converted, by the addition of zinc, into brass or 'yellow metal' sheet, which is marketed in India. The electric energy is generated by means of water tube boilers fired by pulverised fuel, and high speed turbines of a total capacity of 3875 kw.

Two parallel lodes or ore bodies have been developed in the Mosaboni mine, the Main and the Western. They dip at approximately 35° from the horizontal and have been developed approximately north and south for a distance of some 4,000 feet. The grade of ore varies from 2·5 to 3·0 per cent. of copper and at the close of the year 1933 the total ore reserves amounted to 686,402 short tons with an average assay value of 3·06 per cent. of copper. In 1933 there was also an initial production of ore from Dhobani where a lode parallel to that at Mosaboni is being opened up. The figures

of production and value given in Table 39 refer to ore milled and not to ore mined. The figures for the latter are given in successive annual reviews. Table 39 gives the production of copper-ore and copper-matte in India during the quinquennium under consideration. In the previous quinquennium the output of copper-ore from Singhbhum averaged only 11,775 tons annually, but during the present quinquennium with the commencement of smelting at Mosaboni the output of ore has risen from 73,519 tons in 1928 to 181,907 tons in 1933, averaging 137,088 tons yearly.

Hazaribagh district, Bihar and Orissa.

Several attempts have been made within the last 70 years to re-open the old Baragunda copper workings in the Hazaribagh district of Bihar and Orissa. In 1888 the Bengal Baragunda Copper Company turned out 218 tons of refined copper, but the assays of average samples of the ore are not inviting, yielding between 1 and 3 per cent. of copper.

Himalaya.

With reference to copper in the Himalaya, attention may be drawn to notes on the copper-ores of Jammu and Kashmir,[1] on the copper of Garhwal,[2] and to one on a copper deposit near Komai in the Darjeeling district.[3] According to Mr. Middlemiss there are a number of copper occurrences in Jammu and Kashmir, where they are

Jammu and Kashmir.

distributed as lodes with a quartz gangue in Palæozoic slates, or as veins following planes of brecciation in the Great Limestone. In a few places these have been mined in ancient days as in many other parts of India. Some of the deposits discussed by Mr. Middlemiss appear to be new discoveries, and the possibility of—

'working them under modern conditions will depend on the opening up of the country by communication lines, on the co-ordination of related industries, and on the utilisation of by-products'.

The two most important deposits described appear to be those of Shumahal near Hapatnar (33° 50′ : 75° 23′) in the Kashmir valley, and Gainti (33° 5′ : 74° 58′) in the Riasi district. At Shumahal there is a layer of slates impregnated with a multiplicity of small veins and lenticular bodies of quartz with chal-

[1] C. S. Middlemiss, Mineral Survey Reports, Jammu and Kashmir Government, 'Ore deposits of lead, copper, zinc and other metals in Jammu and Kashmir State,' pp. 13-32, (1929).

[2] J. Coggin Brown, *Rec. Geol. Surv. Ind.*, XXXV, p. 35, (1907).

[3] H. H. Hayden, *Rec. Geol. Surv. Ind.*, XXXI, pp. 1-4, (1904): also for copper in the Darjeeling district *see* F. R. Mallet, *Mem. Geol. Surv. Ind.*, XI, pp. 69-83, (1874) and *Rec. Geol. Surv. Ind.*, XV, pp. 56-58, (1887). Also *op. cit.*, LVII, p. 103.

copyrite, which is oxidised at the surface chiefly to malachite and azurite with cuprite. Specimens of ores from the surface and from pits showed from 0·06 to 2·11 per cent. of copper. Attempts to cut the lodes by bore-holes were unsuccessful, so that the quality of these lodes in depth is unknown. At Gainti, which was a new discovery, prospecting work showed that the ore consists of chalcopyrite with malachite, averaging about 2·6 to 2·7 per cent. of copper where tested, and distributed along fracture lines in a particular bed or beds in the Great Limestone series. Specimens of ore have been obtained with 5·6 to 5·8 per cent. of copper.

Work early in this century has proved the existence of lodes of possible value in Sikkim, where the copper is associated with bismuth, antimony, and tellurium, one of the minerals discovered being the rare mineral tetradymite, Bi_2Te_3. Another mineral identified by the late Mr. Blyth [1] in the Geological Survey Laboratory is linnæite, a sulphide of cobalt, Co_3S_4.

Sikkim.

Prospecting licenses and mining leases were secured by Messrs. Burn & Company, in the copper-bearing areas in Sikkim, and extensive prospecting operations were conducted for some years; they were suspended, however, during the war, and have not been resumed. The following notes are from a report made in October, 1908 by Mr. C. Wilkinson, showing the principal results obtained up to that date.[2]

At Bhotang, 44 miles from Siliguri on the road to Gangtok, some old workings were examined and two parallel lodes of pyrrhotite were opened up and found to contain varying quantities of zinc blende, galena, and chalcopyrite. The lodes are disturbed but development work yielded results that were regarded as satisfactory.

At Dikchu, about 7 miles to the north of Gangtok and within a mile of the Gangtok-Lachen road, a distance of 75 miles from Siliguri, a more clearly defined copper lode was discovered. It was found, by opening up the outcrops for a length of 200 feet, along the bed of the Sehchu, that the lode had an average width of 3 feet, bearing 6·14 per cent. of copper. By cutting the vein

[1] *Rec. Geol. Surv. Ind.*, XXXI, pp. 1-4, (1904).

[2] Published with the kind consent, through the late Mr. A. Whyte, of Messrs. Burn & Co.

TABLE 39.—*Production of Copper-ore and Copper-matte during the years 1929 to 1933.*

—	1929.		1930.		1931.		1932.		1933.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Bihar and Orissa—										
Singhbhum (*a*)	73,519	*17,68,415*	119,787	*25,99,709*	144,250	*22,95,025*	165,977	*26,69,565*	181,907	*24,20,038*
Burma—										
Northern Shan States (*b*).	11,303	*50,20,544*	17,146	*45,97,974*	13,437	*32,25,003*	9,729	*19,81,499*	12,550	*30,03,983*
Madras—										
Nellore . .	..	..	..	..	..	..	365	*6,900*	..	..
TOTAL .	**84,822**	*67,88,959*	**136 933**	*71.97,683*	**157,687**	*55,20,028*	**176,071**	*46,57,964*	**194,457**	*54,24,021*
Total value in sterling.	..	*£506,639* (£1 = Rs. 13·4)	..	*£533,162* (£1 = Rs. 13 5)	..	*£408,891* (£1 = Rs.13·5)	..	*£350,223* (£1 = Rs. 13·3)	..	*£407,821* (£1 = Rs. 13·3)

(*a*) Ore milled. (*b*) Copper-matte.

at a greater depth with an adit, it was found that for 80 feet on an average width of 40 inches the lode contained an average content of 6·8 per cent. of copper.

In the Rhotak *colah*, a tributary of the Great Ranjit river, 13 miles by pack road from Darjeeling, there are extensive old workings which have been almost obliterated by landslips. Five samples of the lode, taken at irregular intervals along a length of 500 feet, gave an average of 5·6 per cent. of copper.

At Sirbong, about 1 mile north-east of the junction of the Rhotak and Khani *colahs*, a lode of pyrrhotite containing chalcopyrite was exposed, yielding, for an average thickness of 2 feet 6 inches, 6·45 per cent. of copper, the sampling being continued for about 100 feet along the outcrop.

The Pachikhani mine, which is reputed among the natives to be one of the richest of the mines in Sikkim, has been overwhelmed by a landslip, and has not yet been sufficiently opened for further examination (*see* Mr. Bose's remarks on this mine in *Records, Geological Survey of India,* Vol. XXIV, page 227).

Another deposit was found near Pachikhani on the road from Rungpo to Pakyong, about 7 miles from the former locality. It was found that the chalcopyrite, concentrated within a zone of mica-schist about 4 feet wide, yielded on an average 4 per cent. of copper.

Within 200 yards of the bridge crossing the Rungpo on the road from Rungpo to Rhenok, and about a mile to the north-east of the second of the two Pachikhani mines, there was found a quartzose vein following the foliation-planes of the Daling series and containing 3·97 per cent. of copper for an average thickness of 1 foot; it is considered that this ore could be readily concentrated by hand-picking.

In the neighbourhood of Pakyong in the Pachi *colah* valley, two veins were found cropping out at right angles to the stream and at a distance of 200 yards from each other. The average analysis of the samples collected from one of these lodes gave the following results :—

	Per cent.
Copper	3·30
Iron	11·23
Lead	10·10
Zinc	2·50
Sulphur	11·68
Silica	40·10

The other lode, consisting mainly of galena, varied in thickness from 6 inches to 2 feet, and contained an average of 21·12 per cent. of lead with 5·9 per cent. of zinc.

In 1911 the two most important of these deposits, namely, Bhotang and Dikchu, were examined by the Geological Survey of India.[1] As the result of this examination, development work was resumed at Bhotang with favourable results. Both deposits occur interbedded with the associated rocks, being of the nature of interbedded replacement deposits; but whereas the Bhotang deposit is in a comparatively unmetamorphosed form of the Daling series, the Dikchu deposit occurs in the belt of highly crystalline mica-schists with associated gneisses, forming a boundary zone between the Daling series and the Sikkim gneiss. In both cases, the copper-ore is chalcopyrite, the chief associated sulphide being pyrrhotite. But, especially at Bhotang, galena and blende are also of somewhat common occurrence. The origin and mode of occurrence of these ores appear to be similar to those of the Singhbhum copper lodes. In each area the bodies of copper-ore have been formed by the metasomatic replacement of the associated rocks; in each area also the copper-bearing formations are close to large masses of granitic rocks, from which, one may conjecture, the copper-bearing solutions were derived. In Singhbhum there are numerous basic (epidioritic) dykes associated with both the granites and the metamorphic rocks (schists, quartzites, etc.), and, as an alternative to the derivation of the copper-bearing solutions from the granites, it is possible to suppose them to be closely connected with the basic dykes.

Although the deposits of Sikkim are similar in mode of origin to those of Singhbhum, they differ from them remarkably in the diversity of their mineral contents, which frequently include chalcopyrite, pyrite, pyrrhotite, blende, and galena; in Singhbhum, on the other hand, the copper-lodes show, as a rule, only two prin ipal[2] sulphide minerals, chalcopyrite and pyrite, with traces of chalcocite at higher levels, probably representing a zone of secondary enrichment. In both Sikkim and Singhbhum, azurite, malachite, chrysocolla, and chalcanthite are found in the oxidised zones of the lodes, but in Sikkim, where the slopes are very steep and

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XLII, p. 75, (1912); *see also Proc. As. Soc. Beng.*, N. S., XV, p. cxci, (1919).
[2] But *see* page 265 for nickel minerals.

denudation under the influence of a moist climate and heavy rainfall very rapid, the oxidised zones are much less prominent than in Singhbhum. In Sikkim the sulphide minerals may crop out at the surface in the fresh condition, but this practically never happens in Singhbhum, where one might doubt the existence of copper deposits, were it not for the presence of numerous ancient outcrop workings stained with the green and blue oxidised copper minerals.

One of the obstacles to a successful exploitation of the copper ores of Sikkim or Darjeeling is the inaccessibility of the areas and the lack of adequate communications. A successfully established water-power scheme in either area would add considerably to the prospects of its copper deposits.

Burma.

Copper is found at Bawdwin in the Northern Shan States of Burma. The reserves of copper-ore were reported in 1934 to amount to 250,000 tons, of composition not stated. But the 85,417 tons extracted during 1933-34 averaged 11·9 per cent. of lead, 5·2 per cent. of zinc, 4·22 per cent. of copper and 12·7 ounces of silver to the ton. In addition the reserves of silver-lead-zinc ores in the Shan and Meingtha Lodes average 2·33 per cent. and 1·65 per cent. of copper respectively. There is now a considerable and regular production of copper-matte at the Namtu smelting works of the Burma Corporation, assaying on an average about 41 per cent. of copper, 35 per cent. of lead and 70 oz. of silver to the ton. This matte is being exported to Hamburg for further treatment. The annual output during the five years under review averaged 12,833 tons against 9,051 tons in the previous quinquennium (*see* Table 39). Copper-ore is also found in the Myitkyina and Katha districts, but no regular operations are carried on in either, and no ore-bodies of any value have yet been proved.

Madras.

Old copper workings on an extensive scale are to be seen in Nellore, in the neighbourhood of Garimanipenta (Ganipenta), but are confined mostly to the surface. Some 14 tons of ore were produced during 1926 and 1927 and 365 tons in 1932. The existence of payable ore at appreciable depths has never been investigated.

Mysore.

The 5 tons of copper-ore raised in Mysore State in 1928 came from Biligiri in the Mysore district.

Rajputana and Nepal.

Copper has been mined at several localities in Jaipur, and deposits of unknown value are known to occur in Nepal.

Indian consumption of copper and brass.

That there is plenty of scope for the development of copper deposits in India to satisfy the Indian demand is seen by the magnitude of the imports of copper and brass. The average annual values of these for the period under review are shown in Table 40 together with the exports of Indian copper and brass wares (manufactured from imported metal), and the re-exports of foreign copper and brass and the value of the copper and brass produced in India. From these it is seen that the value of the average annual consumption has been Rs. 1,29,78,592 in the case of copper and Rs. 2,53,27,369 in that of brass, as against Rs. 1,22,19,977 and Rs. 2,52,18,294 respectively in the previous quinquennial period.

During the period under review, the imports have been reduced by almost precisely the amount of the internal production. But the total consumption is still below that of the quinquennium 1919-1923, namely Rs. 2,09,07,779 for copper and Rs. 2,70,10,600 for brass.

TABLE 40.—*Average annual exports and imports of Copper and Brass for the five years 1929-30 to 1933-34.*

	COPPER.		BRASS.	
	Rs.	Rs.	Rs.	Rs.
IMPORTS	..	1,02,93,925	..	1,66,41,132
EXPORTS—				
Of Indian merchandise	39,88,215	..	7,44,408	..
Of foreign merchandise	42,570	..	1,02,827	..
Of Government stores	290	..	251	..
TOTAL EXPORTS	..	40,31,075	..	8,47,486
RETAINED IMPORTS	..	62,62,850	..	1,57,93,646
INTERNAL PRODUCTION	..	67,15,742	..	95,33,723
AVAILABLE FOR CONSUMPTION IN INDIA.	..	1,29,78,592	..	2,53,27,369

Diamonds.

[L. L. FERMOR.]

Notwithstanding the reputation (stretching back even as far as Ptolemy in the European, and further in the Hindu, classics) which India has had as a diamond-producing country, the output of to-day is very small and comparatively unimportant. The diamonds of ancient days were reputed to come from the so-called Golconda mines. Golconda, as a fact, was merely the mart at which the stones were sold or bartered. The Koh-i-nur, presented to Queen Victoria on the annexation of the Punjab in 1849 and now one of the Crown jewels, is said to have been once in the possession of the Emperor Aurangzeb, and was, according to tradition, found somewhere near the Kistna river. The Regent or Pitt diamond, which figured in the State sword worn by Napoleon, is said to have come from the Kistna district. The places which, according to accounts, have been most productive in the past form three great groups, each in association with the old unfossiliferous rocks of probable pre-Cambrian age, known as the Purana group, and distinguished locally as the Cuddapah and Karnul systems in South India, and as the Vindhyan system in the northern part of the Peninsula.

Distribution in India.

The southern of the three groups of diamond occurrences includes localities, with apparently authentic records, in the districts of Cuddapah, Anantapur, Bellary, Karnul, Kistna and Godavari. Loose stones have been picked up on the surface of the ground, and found in deposits of alluvium and in workings that have been undertaken in the so-called Banganapalle stage of the Karnul series of strata.

Southern group of occurrences.

Although no official returns are available, private but unconfirmed reports indicate that every year a certain number of valuable diamonds are picked up after showers of rain in the neighbourhood of Wajra Karur in the Anantapur district of the Madras Presidency. One was found some years ago in a field north of a volcanic pipe, calculated to be of sufficient size to yield a table diamond of sixty carats, worth about a lakh of rupees.

During 1910-1912, the late Mr. A. Ghose prospected a concession at Viraypalle in the Karnul district. The bed of diamond-bearing conglomerate was found to vary between 2 inches and 2 feet in

thickness and to yield from $\frac{1}{8}$ to $\frac{1}{2}$ carat of diamond from each load of 16 cubic feet, most of the diamonds obtained being perfect crystals of fine quality and free from flaws. During the past twenty years there appears to have been no output in Madras.

Eastern group of occurrences.

In the second group of occurrences, in the Mahanadi valley, the stones have been found in the alluvium of the Sambalpur and Chanda districts, but, though strata similar to those of the Vindhyans and Karnuls are known in this area, no diamonds have been found in these older rocks.

Central Indian occurrences.

The third group of occurrences occupies a tract some sixty miles long by ten miles wide, with the Vindhyan conglomerates near Panna as the centre. The diamond-mining industry still persists in this area, both in the old conglomerate of Vindhyan age, and in the alluvium derived therefrom. The States in which diamonds are found are Panna, Charkhari, Bijawar, Ajaigarh, Kothi, Pathar, Kachhar, Baraunda, and Chobepur.

The following scale of strata will give an idea of the position of the diamantiferous beds with reference to the Upper Vindhyan rocks exposed in the Central India area—

BHANDER SERIES . . .	Upper Bhander sandstone. Sirbu shales. Lower Bhander sandstone. Bhander limestones. Ganugrarh shales.
Diamantiferous horizon.	
REWA SERIES	Upper Rewa sandstone. Jhiri shales. Lower Rewa sandstone. Panna shales.
Diamantiferous horizon.	
KAIMUR SERIES . . .	Upper Kaimur sandstone. Kaimur conglomerate. Bijaigarh shales. Lower Kaimur sandstone.

The following is a summary of the principal results of a study by Mr. E. Vredenburg,[1] of the diamond-fields of Central India. In the neighbourhood of Panna the principal diamond-bearing stratum is a thin layer of conglomerate, locally known as *mudda*, lying between the Upper Kaimur sandstone and the Panna shales.

[1] *Rec. Geol. Surv. Ind.*, XXXIII, pp. 261-314, (1906).

The conglomerate is seldom thicker than two feet and does not form a continuous bed. Further east, in the neighbourhood of Itwa, the diamond-bearing conglomerate does not rest directly on the Kaimur sandstone, but is separated from it by a 20 to 25-foot bed of shales and limestone. Another diamantiferous conglomerate occurs above the Rewa sandstones and under the Bhander series. This conglomerate differs from that below the Rewa series in the abundance of pebbles of vein quartz, instead of the different varieties of jasper found so commonly in the main diamantiferous conglomerate near Panna.

The diamonds in these conglomerates, like the associated large pebbles of lighter rocks, are derived from older rocks, and the original home of the gem is still unknown, though a precise recognition of the associated pebbles will gradually indicate the direction in which the mother-rock once occurred and possibly still exists. The most characteristic pebbles in the diamond-bearing conglomerates are the jasper pebbles derived from the Bijawar formation and the vein quartz similar to that traversing the Bundelkhand granites, the latter being especially abundant in the conglomerate lying above the Rewa sandstone.

Besides the diamonds lying still embedded in the conglomerates, others are found in the neighbouring detritus derived from the disintegration of the Vindhyan beds. The workings are developed accordingly—some with a view to the removal of the undisturbed conglomerate, and others with the intention of recovering the diamonds included in the more recently distributed detritus.

The undisturbed conglomerate is often covered by considerable thicknesses of younger Vindhyan rocks, and is reached by workings which are often, but not always, deep; these may be called 'direct workings'. In other places the overlying younger rocks have been removed by weather agents, and the conglomerate thus exposed at the surface is available for 'shallow workings'. In the detritus removed from the original conglomerate and deposited in river valleys, the diamonds may be reached by superficial, shallow, or comparatively deep workings, and they may be all spoken of conveniently as 'alluvial workings'.

Production.

The figures returned for diamonds relate to the production in the Central Indian States of Panna, Charkhari, Ajaigarh, Bijawar, and Baraunda, of which nearly the whole comes from Panna State. The production during the

five years under review is shown in Table 41, the average being 1,436·8 carats worth Rs. 74,040 as compared with 223·87 carats worth Rs. 36,237 during the previous five years and 161·94 carats worth Rs. 92,124 during the quinquennium 1919-1923.

TABLE 41.—*Production of Diamonds in Central India during the years 1929 to 1933.*

Year.	Quantity.	*Value.*	Daily labour.
	Carats.	*Rs.*	Persons.
1929	1,627·5	*1,27,101*	1,972
1930	1,321·2	*72,533*	1,354
1931	639·0	*34,683*	894
1932	1,254·1	*72,189*	1,223
1933	2,342·0	*63,695*	2,163
Average	*1,436·8*	*74,040*	*1,521* *

Gold.[1]

[L. L. FERMOR.]

Comparison with other countries.

The production of gold in the world during 1933 was about 25,000,000 fine ounces troy, valued, with the average price of gold of 124·8 shillings per fine ounce troy, at about £156,000,000, as compared with 19,300,000 ounces in 1928 valued, with gold at 84·933 shillings per ounce, at about £82,000,000. India, with a production of 336,100 ounces, produced only about 1·35 per cent. of the total. During the four years 1904 to 1907, India occupied the seventh position amongst the leading gold-producing countries

[1] A general account of the gold occurrences of India and Burma is given in Dr. Maclaren's 'Gold' pp. 238-270, (1908); considerable use has been made of this in preparing this article.

For a brief summary of 'The Gold Resources of India', *see* L. L. Fermor, 'The Gold Resources of the World', XVth International Geological Congress, South Africa, (1929), pp. 185-201.

of the world; in 1908 she fell to the eighth position, the countries of higher production being the Union of South Africa, United States of America, Canada, Mexico, Russia, Rhodesia and Australia. Up to 1918, she still occupied the eighth position, but in 1920 she rose to the seventh position, Russia's production having decreased. In 1925, the production of gold in Russia was again higher than that of India, which again fell into the eighth position. She maintained this position up to 1927, but by 1933, with a somewhat decreased production, in spite of the high price of gold, India had fallen to the tenth place (*see* Table 42), owing to an increased production from Japan and Korea.

TABLE 42.—*Production of Gold by the chief gold-producing countries during 1933.*[1]

Serial No.	Countries.	Fine ounces.
1	Union of South Africa	11,013,712
2	Canada	2,949,309
3	Russia	2,500,000
4	United States of America	2,152,755
5	Australia	825,930
6	Rhodesia (Northern and Southern)	645,087
7	Mexico	637,727
8	Japan	433,800
9	Korea	370,000
10	India	336,100
11	Gold Coast	305,908
12	Colombia	298,243
13	Belgian Congo	283,081
14	Philippine Islands	282,836
15	New Zealand	161,755
16	Chile	147,052
17	Sweden	135,937
18	Roumania	127,147
19	New Guinea	121,913
20	Brazil	110,000
21	Other countries	1,161,708
	Total	**25,000,000**

Provincial production.

Table 43 shows the provincial production for India during the five years under review. In 1904 no less than 98·2 per cent. (by value) of the Indian output was returned by Mysore, and 1·7 per cent. by the Nizam's

[1] Figures taken from *The Mineral Industry of the British Empire and Foreign Countries* (Imperial Institute) Statistical Summary, 1931-33.

Dominions, leaving only 0·1 per cent. as the production of districts directly under British administration. By 1908, owing to the development of reef mining in Dharwar and dredging in Myitkyina, the proportion derived from districts directly under British administration had risen to 2·7 per cent.; of the remainder, 94·4 per cent. came from Mysore and 2·9 per cent. from the Nizam's dominions. During the quinquennium 1919-1923, with the cessation of work in Hyderabad, the Mysore proportion rose to 97·6 per cent., and in 1923 after the cessation of mining operations in the Anantapur district, Mysore produced 99·6 per cent. of the total. The increased proportion from Mysore was, however, on a lower total, and actually there was a decline in production from a peak in 1920 of £2,194,595 (the previous peak was £2,373,457 in 1905 on a production of 616,758 standard ounces) on 482,958 standard ounces to 375,983 fine ounces valued at £1,604,603 in 1928. During the present quinquennium the total output of gold in India fell to 329,232 ozs. in 1930 and recovered only very slightly to 336,108 ozs. in 1933. This is in spite of the greatly enhanced price of gold during 1932 and 1933, causing the output of 1933 to be valued at £2,078,201. The Mysore proportion in 1933 was 99·9 per cent. of the total, 225 ounces being produced in Singhbhum and 109·4 ounces, mainly alluvial, in other parts of India.

Vein gold: development of the Kolar field.

The production of the Mysore State is solely derived from the Kolar district where a main reef and a few subsidiary branches are being worked at present. The main reef, the average width of which is about 3 feet, is payably auriferous throughout its length of about five miles.

The development of the Kolar goldfield is one of the romances of modern mining. As has been the case with all other known auriferous deposits in Peninsular India, the attention of Europeans was directed to this field by the occurrence of numerous old workings along the strike of the principal lode. In 1873, Mr. M. F. Lavelle of Bangalore obtained from the Mysore Government the concession to mine in the Kolar district, and after preliminary operations, during which he discovered that large capital would be required, he transferred his concession to the late Major-General D. de la Poer Beresford, who with some friends formed a syndicate known as the Kolar Concessionaires. In 1880, the Concessionaires secured the aid of the well-known firm of mining

Table 43.—Quantity and value of Gold produced in India during the years 1929 to 1933.

PROVINCE.	1929.		1930.		1931.		1932.		1933.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Ozs.	*Rs.*	Ozs.	*Rs.*	Ozs.	*Rs.*	Ozs.	*Rs.*	Ozs.	*Rs.*
Bihar and Orissa—										
Manbhum	..	..	..	..	..	..	..	..	42·0	*2,988*
Singhbhum	30·0	*1,500*	30·0	*1,500*	..	..	50·0	*3,650*	225·0	*16,750*
Burma—										
Katha	23·5	*1,420*	44·8	*3,225*	18·8	*1,005*	18 2	*950*	31·0	*1,665*
Upper Chindwin	12·6	*1,102*	14·8	*1,225*	18·0	*960*	28·4	*2,649*	21·0	*1,960*
Kashmir	56·3	*2,700*	..	..	..	..	..	..	..	..
Mysore (a)	363,741·4	*2,06,57,238*	329,133·9	*1,86,78,794*	330,437·5	*2,07,99,131*	329,574·9	*2,53,43,443*	335,773·9	*2,76,15,478*
Punjab	1·9	*108*	6·9	*367*	10 0	*583*	6·6	*480*	10·3	*825*
United Provinces	3·7	*200*	1·9	*100*	4·5	*264*	3·6	*266*	5·1	*405*
Total	**363,869 4**	*2,06,64,268*	**329,232 3**	*1,86,85,211*	**330,488·8**	*2,08,01,943*	**329,681·7**	*2,53,51,438*	**336,106·3**	*2,76,40,071*
Value in Sterling	..	*£1,542,109 (£1 = Rs. 13·4)*	..	*£1,384,090 (£1 = Rs. 13·5)*	..	*£1,540,885 (£1 = Rs. 13·5)*	..	*£1,906,123 (£1 = Rs. 13·3)*	..	*£2,078,201 (£1 = Rs. 13·3).*

(a) Fine gold.

engineers, Messrs. John Taylor & Sons of London, and in that year were floated three out of the four companies that are still operating, *viz.*, the Mysore, Ooregum and Nundydroog companies, while the Champion Reef company was floated in 1889. The Balaghat company, which was floated in 1881, went into liquidation in 1932 and was sold on 1st May, 1932, to the Nundydroog Mines, Ltd., the latter company undertaking to mine and test the ore reserves remaining in the Balaghat mine. The features of the auriferous deposits were not at first grasped and much money was expended in mining in barren ground and amidst ancient workings, which were eventually found to reach to a depth of 300 feet. By this time the resources of the various companies were mostly exhausted, and it was only a final effort of the Mysore Company that disclosed that the Champion lode persisted in depth, instead of being cut out in depth as was previously thought. By 1885, the success of the Kolar goldfield was assured and in a short time a large and flourishing town arose and Kolar is now one of the model mining towns of the world, with modern conditions of life, and a group of successful and efficiently managed mines, in which all the latest methods of mining are adopted for the successful extraction of the gold quartz at increasing depths and under increasingly difficult conditions of work due to heat and rock pressures.[1]

The deepest mines are Champion Reef and Ooregum, which reached vertical depths of 7,410 and 7,334 feet respectively on the 31st December 1933, the Champion Reef being the third deepest mine in the world. The development in depth in Kolar has disclosed the continuity of the reef and a number of payable shoots of ore has been opened up. In fact the indications are that in the deepest portions of the mines the auriferous quartz continues with the same type of distribution as at higher levels, and as far as is known, it is possible that the gold-ores may continue to as great a depth as it is practicable to work in face of increasing physical difficulties due to high temperatures and the strained conditions of the rocks. The figures given below repre-

[1] The following account of the Kolar goldfield during the quinquennium under review is taken from an unpublished report entitled 'A Brief Note on the Working of the Kolar goldfield for the years 1924 to 1928' by H. Bocquet, J. P., Chief Inspector of Mines in Mysore, brought up to date by Mr. C. F. S. Rau, the present Chief Inspector of Mines in Mysore.

sent the yield in pennyweights of fine gold per short ton of the four working mines in the years 1924, 1929 and 1933 respectively :—[1]

	1924.	1929.	1933.
	Dwts.	Dwts.	Dwts.
Mysore	10·10	8·20	10·34
Champion Reef	8·33	10·60	10·21
Ooregum	13·16	8·45	5·27
Nundydroog	8·81	10·25	10·80

Rockbursts continue to be a source of anxiety, but it is gratifying to note that the number of accidents due to this cause shows a gradual decrease and that the steps now taken to minimise their effects have to a large extent proved successful. All important shafts are brick or concrete-lined. In the stoping sections, the old practice of heavy timbering and filling with waste rock has been replaced by packed crib sets and packwalls.

Owing to their great depths and the existing high rock temperatures—between 124°F. and 128°F. in the deeper workings (129·8°F. in the 78th level of Champion Reef mine)—the problem of ventilation continues to be an extremely difficult one. It has been partly solved by sinking deep, circular brick-lined shafts, 18 feet in diameter, from surface, with either smooth-lined elliptical or circular shafts for the secondary stage, and by the use of large electrically driven fans to help the main air currents and smaller fans and blowers for special places. There are five of these brick-lined shafts on the field sunk from surface, of which that on the Ooregum mine, completed about 10 years ago, is the deepest, *viz.*, 4,680 feet vertical. In spite of the increased volume of air, greater velocity, better circulation and decreased humidity, some of the working points are uncomfortably hot in the deeper levels.

The ore is not refractory and yields its gold to a simple combination of blanket concentration, amalgamation and cyaniding; 'all-sliming' is gradually becoming the general practice.

During the five years under review, the annual tonnage crushed fell from 659,725 tons in 1929 to 581,991 tons in 1931 and again gradually rose to 659,769 tons in 1933.

[1] *See* also *Rec. Geol. Surv. Ind.*, XLVI, p. 87, for similar data for 1899 and 1913.

In 1905, the gold yield reached a maximum value of £2,373,457 the largest ever recorded in the history of the field. Since then there have been noticeable fluctuations in the value of the output; in 1923 it sank to £1,752,334 but again recovered slightly in 1924. For the five years under review, the value of the gold extracted was £8,520,550, which is more by £139,111 than the value for the preceding five years. This increase is due to the high price of gold obtained in the market since September, 1931 when England went off the gold standard.

In 1905, the dividends paid reached their maximum value, *viz.*, £1,066,615 for the whole period of the industry; there was then a marked annual decline to £749,398 in 1912. From that date a further decline commenced, the lowest figures reached being £179,000 in 1930. Since that date, there has been a grádual rise with moderate fluctuations, the dividends paid during the five years under review being £1,573,761 compared with £1,543,393 paid during the previous five years. For the same period, dividends have been paid by all the five mines, *viz.*, the Mysore, Champion Reef, Ooregum, and Nundydroog; and by Balaghat, up till the liquidation of the company.

No exploratory or mining work for gold has been done by other companies on the Kolar goldfield or elsewhere in the Mysore State during the last five years.

The introduction of hydro-electric power from the the Cauvery Falls, the first stage of which was completed about the middle of 1902 and designed for the conveyance of 4,000 H. P. over a double line 92 miles long, has gradually been extended, and in 1933 the generating plant supplied 155 motors aggregating 22,306·5 N. H. P. This supply is continuous, even in years of lean rainfall, due to the completion of Krishnarajasagara dam.

The Kolar Mines Power Station, Ltd., formed in 1903, continues to purchase power from the Government Station and supply it to the mines by transforming it to the necessary requirements for lighting and driving of motors used intermittently. An emergency steam plant for generating power in case of failure of the Government supply is always kept in readiness in the power house and within half an hour power supply for the essential plant can be restored.

The water-supply scheme from the Bathamangala tank (some six miles from the field) undertaken by the Mysore Government

has ensured a regular supply of filtered water sufficient for all purposes. The pumping plant has been electrified.

Table 44 shows various statistics of production for the Kolar field both for the period under review and for the previous quinquennium :—

TABLE 44.—*Statistics of production, Kolar goldfield.*

Year.	Tonnage crushed.	Value of Bullion extracted.	Dividends paid.	Royalty paid.
		£	£	£
1924	686,273	1,833,556	305,064	95,808
1925	692,933	1,684,619	309,791	91,129
1926	640,955	1,631,412	309,168	88,904
1927	638,556	1,627,777	311,917	88,846
1928	652,949	1,604,075	307,453	87,531
Total .	**3,311,666**	**8,381,439**	**1,543,393**	**452,218**

Year.	Tonnage crushed.	Value of Bullion extracted.	Dividends paid.	Royalty paid.
		£	£	£
1929	659,725	1,550,356	270,545	83,880
1930	592,157	1,396,146	179,000	74,060
1931	581,991	1,561,541	219,011	83,087
1932*	620,835	1,926,505	412,866	105,776
1933	659,769	2,086,002	492,339	116,117
Total .	**3,114,477**	**8,520,550**	**1,573,761**	**462,920**

* On 1st May 1932, the Balaghat Mine went into voluntary liquidation and ceased operations.

	£
Total value of gold produced from 1882 to 1933 . . .	77,300,111
Total dividends paid from 1882 to 1933	23,425,479
Royalty paid to Mysore Government from 1882 to 1933 inclusive	4,089,110

The work on the field is carried on by Europeans, Anglo-Indians and Indians in the following proportions, calculated from the number employed during the year 1933, the latest for which figures are available :—

	Per cent.
Europeans (including Italian miners)	1·65
Anglo-Indians	2·08
Indians : men	88·31
Indians : women (employed only on the surface) . . .	5·55
Indians : children (under 12 years : employed only on the surface)	2·41

The following table indicates the risks attendant on mining in the Mysore State :—

TABLE 45.—*Fatal accidents in Kolar mines for the years 1929 to 1933.*

Year.	Number of persons employed.	Death rate per 1,000 employed.	Death rate per £100,000 worth of gold obtained.
1929	18,454	3 74	4·46
1930	17,312	2·31	2·86
1931	18,388	7·12	9·32
1932	18,816	3·93	5·28
1933	20,263	2·67	3·78
Average .	*18,647*	*3·95*	*5·14*

Hyderabad (Nizam's Dominions).

In 1901, a company was floated to work the Hutti goldfield situated on the Maski band of Dharwar schists in the Lingsagar district of the Nizam's Dominions. This company, the Hutti (Nizam's) Gold Mines, Limited, was an offshoot of the Hyderabad (Deccan) Company. Crushing with ten head of stamps was commenced in 1903, with a production of 3,809 ozs. of gold that year. Subsequently the number of stamps was increased to 30. The average output during the period 1914-1918 was 16,539 ozs. valued at £63,463. During the quinquennium 1919-1923, the mines were worked up to the first quarter of 1920, when operations ceased.

In 1905, another company known as the Topuldodi (Nizam's) Gold Mines, Limited, with a capital of £90,000 was formed to take over from the Hutti Company an option held on the Topuldodi block in the Raichur district of the Nizam's Dominions. During 1908, 2,132 ozs. of gold, worth £8,379 were produced. But as the ore developed in the mine proved to be of very low grade, the mine was closed down, and its assets transferred to the Hutti Company.

The Dharwar gold-field.

A third Indian field on which work was actively prosecuted during the earlier part of the period 1909-13 is the Dharwar field, situated on the Gadag band of Dharwar schists, partly in the Dharwar district and partly in the Sangli State, both of which lie in the Bombay Presidency. In spite of the expenditure of much capital in very thorough development operations the reefs were found too poor to work and the mines were abandoned in 1911.

Anantapur.

In 1902, Mr. E. W. Wetherell, of the Mysore Geological Department, discovered a previously unknown belt of Dharwar schists stretching in a north and south direction for some 32 miles through the Anantapur district of Madras, but just touching the north-east corner of the Pavagada *taluk* of the Tumkur district of Mysore. Several large quartz reefs occur in this belt, and near the village of Ramgiri old gold workings were found. The gold occurs in quartz veins principally in chloritic and argillaceous schists. A company called the Anantapur Gold Field, Limited, was formed in 1905. This led to the formation of the North Anantapur Gold Mines, Limited, and the Jibutil Gold Mines of Anantapur, Limited. The Jibutil Gold Mines of Anantapur ceased mining operations in September, 1924.

The North Anantapur Gold Mines, Limited, after carrying on vigorous development work, ceased mining operations on the original area in July, 1922. These mines, which were situated in the Dharmavaram *taluk* of Anantapur district, produced 44,678 ounces of fine gold during the quinquennium 1919-1923. In 1925, small quantities of gold were extracted from the dumps by cyanide treatment, but work was finally suspended in June, 1925. The total fine gold produced from these mines since the commencement of operations has been 136,739 ounces. Meanwhile, as a result of prospecting operations in 1922, by this company, ancient gold workings were discovered in the Gooty *taluk* of the Anantapur district some 35 miles north of the old North Anantapur mine.

Exploratory work was carried on in the area and finally, in 1926, the North Anantapur Gold Mines, Limited, applied for a mining lease near the villages of Rampuram and Vemkatampalli in Gooty *taluk*. Gold was first extracted from this area in 1926. The extraction of gold ceased in August, 1927, after which date mining operations were permanently suspended.

The Nilgiris.

The Nilgiris, after many vicissitudes, have ceased to be a mining area: but some native workers are reported to be making a living by roughly treating the waste heaps, from which they extract a small quantity of gold.

Salem district.

Auriferous quartz was reported to have been found at Matagondapalli about 10 miles south-west of Hosur in the Salem district. An assay, done in the Geological Survey Laboratory, of some of the quartz from this area, however, showed no trace of gold.

Southern Shan States.

Attention has recently been drawn to old workings for gold in beds of marbles and siliceous limestone on the western slopes of the Mwe-daw hill mass (20° 39′: 96° 28′) to the west of Kalaw in the Southern Shan States. A prospecting license for this area has been acquired by Mr. E. C. M. Garrett of the Shan States Silver-Lead Corporation, Ltd., and transferred to the Kafue Copper Development Co., Ltd., a company operating in South Africa. Investigations to date are said to have given encouraging results, but details are not to hand. The origin of the gold is thought to be due to dioritic and granitic intrusions into the Kalaw coal measures, as a result of which limestone beds have been either completely silicified or metamorphosed to marble and large quantities of wollastonite have been produced. The highest gold values have been obtained in a highly crushed and recemented fault-rock accompanied by secondarily deposited silica, hematite and malachite.[1]

Gold in sulphide lodes.

Besides occurring in the free state in quartz veins, as in the areas noticed above, gold is sometimes found in sulphide lodes enclosed in the sulphide minerals. Thus, gold occurs in Sikkim among the mixed sulphide lodes (chalcopyrite, pyrite, pyrrhotite, blende, etc.) and in the copper-bearing lodes of Sleemanabad in the Jubbulpore district of the Central Provinces. Assays in the latter case have occasionally shown amounts as high as 15 dwts. per ton.

[1] V. P. Sondhi, *Rec. Geol. Surv. Ind.*, LXVII, p. 31, (1933).

Alluvial gold-washing is carried on in Assam, Bihar and Orissa and many other places in the Indian Empire, but the fact that the washers invariably combine this pursuit with other occupations, and because the individual return is exceedingly small and is locally absorbed for jewellery, complete returns are not available. These, so far as they go, give little hope of the discovery of rich alluvial deposits in Peninsular India, or indeed in any part of India affected by the monsoon rains and dependent on them alone for the supply of the rivers. For concentration of gold, a comparatively equable current is essential—a condition rarely obtainable in the gravel river beds of India, where alone gold would be found. for these are almost dry in the cold weather and roaring torrents in the rains. The greater possibilities of dredging on the Irrawaddy appear to arise from the fact that the waters of that river are derived from ranges where, even in the cold weather. there is a heavy rainfall. But, in the case of the Irrawaddy, the flood waters, which prevail during the rains, have in the past seriously interfered with dredging operations.

Alluvial gold.

In Upper Assam, tributaries such as the Subansiri, that flow from the north into the Brahmaputra, carry small quantities of gold.[1] One small bar near the mouth of the Subansiri gorge was found to contain more than one dwt. per cubic yard ; but the quantity of gravel available was very small. It is probable that some of the gold of this region is derived immediately from the Tipam (Siwalik) sandstones, and that the source of the gold in the Lohit branch of the Brahmaputra is to be sought in the metamorphic rocks of the Miju ranges.

Assam.

In the Chota Nagpur division of Bihar and Orissa, alluvial gold is found widely distributed, but the gold-washing is of most importance in the Singhbhum and Manbhum districts, and is chiefly confined to the valley of the Subarnarekha ('golden-streaked ') river and its tributaries. The average earnings per person employed amount to only As. 1½ to As. 2 a day.

Chota Nagpur.

The result of the work of Dr. Maclaren[2] and of other members of the Geological Survey was to show that nowhere in Chota Nagpur had gold deposits—either alluvial or vein—been found worth work-

[1] J. M. Maclaren, *Rec. Geol. Surv. Ind.*, XXXI, pp. 179-232, (1904).
[2] *Ibid.*, pp. 59-91.

ing on European lines. Not long ago, however, interest in that area revived, and The Dalbhoom Gold and Minerals Prospecting Company, Limited, was promoted to work gold mines in the Dhalbhum Estate. A modest output of 450 ounces was first made in 1915, but rose in 1917 to 2,462 ounces: it fell to 2,085 ounces in 1918, and to 173 ounces in 1919. The mines were finally closed in 1920. The gold occurred in veins of blue-grey quartz in Dharwarian phyllites round Kundrakocha, averaging in the richer lodes about 4 dwts. But at one locality (Porojarna) an ore shoot averaging 20 dwts. was discovered. This ore was in places extraordinarily rich in visible gold sometimes assaying several hundred ounces to the ton. The average assay of the ore crushed was about 17 dwts., and of the total amount of some 6,000 ounces recovered, all but 250 ounces came from the Porojarna pocket.[1] The small production of gold from Singhbhum during this quinquennium, especially of 225 ozs. in 1933, is understood to be due to further work at Porojarna under the stimulus of the high price of gold.

Burma native gold-washing.[2]

The native gold-washing industry is carried on from year to year in several districts of Burma, usually by only a few people in each district; the number so engaged varies from year to year partly in accordance with the character of the seasons. No accurate figures of production are available. In Table 43, returns are shown of production from the Katha and Upper Chindwin districts. In 1928, the total amount from these districts was 52 ounces. Besides the gold produced from the above districts, small quantities of the order of say 10 to 15 ounces are produced from the Lower Chindwin district from tributaries of the Yama, Yewa, and Hmyaing *chaungs*[3]; washing is carried on for about two months during the rains, and the gold-washers are said to win about 4 annas worth of gold per day. Similar gold-washing operations of minor importance are carried on in the Myitkyina district from the sands of the Uru river, between Pantin and Namon.[4] The Uru boulder

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, LIII, p. 269, (1921).

[2] An excellent account of the gold occurrences of Burma has recently appeared by Dr. Coggin Brown: 'Gold in Burma and the Shan States, *Mining Magazine*, LII, pp. 9-20, 82-92, (1935).

[3] *Ibid.*, LXII, p. 52, (1929).

[4] *Rec. Geol. Surv. Ind.*, LXII, p. 53, (1929).

conglomerate is also washed for gold by Shan women, who can collect from 6 to 7 annas worth in a morning's work.

Burma gold-dredging : the Irrawaddy.

The former gold-dredging on the upper reaches of the Irrawaddy was largely due to the enterprise of Mr. W. R. Moore, who, in association with Captain J. Terndrup, was granted in 1901, a five years' license for dredging within the bed of the river for a stretch of some 120 miles from the confluence above Myitkyina to the mouth of the Taiping above Bhamo. In 1904, the license was extended for a period of thirty years and restricted to about 88 miles of the river from Sinbo to the confluence, while sanction was given at the same time to transfer the concession to the Burma Gold Dredging Company, which was registered in Rangoon in 1903. In 1907, permission was given to alter the limits of the concession by exchanging 15 miles of the lower end for 10 miles along the N'mai-hka and 5 miles along the Mali-hka. Application was subsequently made for a further exchange of the Irrawaddy part of the concession for 15 miles along the eastern river N'mai-hka. This company was liquidated in 1911, and a new company formed, called the Burma Gold Dredging Company, 1911, Limited.

For the greater part of the period 1909-1913, five dredgers were at work, but the results did not come up to expectations. Expenses were cut down considerably by the substitution of Kachin for Australian skilled labour, but the output was still considerably below that of 1909; this was attributed to the poor quality of the wash remaining to be worked in the bed of the river. The average annual outturn for the period 1914-1918 was 1,951 ounces. After 1918, there was no production of gold, and the company closed down dredging operations altogether.

The gold-bearing alluvium is coarse gravel with the gold disseminated fairly uniformly. The average value of the gravel was about 3 grains (6 annas) per cubic yard. Small quantitites of platinum and platinoid metals are recovered with the gold.

The Chindwin.

The alluvial stretches of the Chindwin river have been found to contain gold at many points, but systematic prospecting has in most cases shown them to be valueless as dredging propositions, although they are a source of income to the native gold washers.[1] A concession for 180 miles

[1] H. S. Bion, *Rec. Geol. Surv. Ind.*, XLIII, p. 341, (1913)

of the Lower Chindwin river, stretching from Minsin to Homalin, was granted about 1903, to the Burma Mines Development and Agency, and in 1905, transferred to the Mandalay Gold Dredging Company. A dredger was obtained, but became stranded while being towed up the Chindwin river, and no further work was attempted.

The Uru, a tributary of the Upper Chindwin, has also been prospected for alluvial gold, but with little success so far.

The Namma.

In 1905, the Namma Gold Dredging Company, Limited, with a capital of £70,000 (£55,000 issued, of which £30,000 went to vendors) was floated in London to work two stretches of the Namma river, a tributary of the Salween, in the Shan States. A careful preliminary investigation had indicated the existence of approximately 40,000,000 cubic yards of gravel averaging 5·43 grains of fine gold per cubic yard. A steam dredger was purchased and floated in a paddock on the Upper Namma, but it was then found that the deposit was unfitted for this mode of exploitation. It consists of gravel and boulders embedded in a stiff clay, hardened by calcareous tufa derived from the limestone forming the sides of the valley, and is therefore not sufficiently loose to enable the buckets of the dredger to excavate it. The venture, therefore, ended in failure.

The alluvial gold deposits of Loi Twang in the Shan States, worked by native washers, have been examined in detail by Mr. T. D. La Touche and found to be of no commercial value.[1] Alluvial deposits examined by Dr. J. C. Brown, in Mong Long, Hsipaw State, were also found to be too poor generally to be worth exploitation, although small patches were found to contain occasionally over 9 grains of gold to the cubic yard.[2]

Other Burmese rivers to which attention has been directed by European prospectors, without any tangible results so far, are the More Chaung, Taiping, and Shweli, tributaries of the Irrawaddy; the Upper Chindwin; the Salween; and the streams of Tavoy, where gold has been found associated with tinstone.

The Central Provinces.

Alluvial gold occurs in the sands and gravels of many of the rivers and streams of the Central Provinces, particularly in those that drain down from or run over areas where the ancient crystalline and metamorphic rocks

[1] *Ibid.*, XXXV, pp. 102-113, (1907).
[2] *Ibid.*, XLII, p. 37, (1912).

crop out. According to an 'Industrial Monograph on Gold and Silverware in the Central Provinces' by H. Nunn, I.C.S., published at Allahabad in 1904, which contains also the best account yet published of the native gold-washing industry of that province, gold-washing has been carried on at various times in the following districts :—Balaghat, Bhandara, Bilaspur, Chanda, Jubbulporé, Mandla, Nagpur, Raipur, Sambalpur, and Seoni. From the report quoted it appears that in addition to the washers of auriferous sands, there are people engaged in a cognate industry, consisting of the extraction of gold and silver particles, calledin England 'lemel', from the dust of a *sunar's* shop and furnace by a two-fold process, first of actual winnowing, and then of washing in a river. The resultant gold is treated by refining processes. The persons practising this 'lemel' washing, which is recorded for the Balaghat, Bilas pur, and Hoshangabad districts, are Mahomedans, and it is desirable to distinguish their occupation from that of the gold-washers proper, although there is doubtless at times a certain overlapping of the two occupations. The gold-washers are variously known in different parts of the province as *jharas*, *jharias*, *sonjharas*, *sonjharias*, and *sonzaras*. The report cited gives a full account of the methods of washing and treating the gold as practised in the Tirora *tahsil* of the Bhandara district. The whole gold industry of the Central Provinces, however, is small and no reliable figures for output are available. It is not likely that more than 200 ounces are won annually.

Kashmir.

Washing for alluvial gold is practised along the valley of the Indus in the Gilgit and Baltistan divisions of Jammu and Kashmir State. In Skardo (Baltistan) and in the Indus river in Gilgit the washing of ancient gravels is carried on on quite an extensive scale. In the old river terraces of the Dras valley actual mining operations have in former years been undertaken to excavate the gold-bearing bands. There are no figures for production in the years 1924 and 1925. There was an output of 60 ounces in 1928 and of 56·3 ounces in 1929, since when there has been no recorded production. At Kargil in Ladakh gold-washing was carried on, and very small quantities of gold extracted in 1926 and 1927 (the gold extracted in 1927 was valued at 10 rupees) but there are no returns for 1928. A small quantity of alluvial gold is said to have been obtained formerly by Tibetans

from sub-recent gravels on the Para river on the border between Rupshu and the Tibetan province of To-tso.[1]

Punjab.

Gold-washing is carried on also in some of the Punjab rivers, especially the Indus, in the Attock, Ambala, and Jhelum districts, and the production for the previous quinquennium totals 180·6 ounces, giving an average annual figure of 36·1 ounces. During the present quinquennium, however, the output was only 35·7 ounces.

United Provinces.

In the United Provinces, the gold-washing industry was reported in 1904 as employing about 100 workers in the Nagina *tahsil* of Bijnor district, but no returns are available of recent years from this area. The small quantities of gold reported in Table 43 represent the result of washings of alluvial gold from the Sona *nadi* close to the south-west border of British Garhwal, near Kalagarh, where the river passes from British Garhwal into the Bijnor district. Alluvial gold has in former years been reported also from Naini Tal district. The total production during the quinquennium was 18·8 ounces.

Graphite.

[L. L. Fermor.]

Mode of occurrence.

Graphite occurs in small quantities in various parts of India—in the khondalite series of rocks in the Vizagapatam hill-tracts and adjoining Orissa Feudatory States, in a corresponding series of rocks in Coorg, in the Godavari district of the Madras Presidency, in the Mogok Stone Tract in Upper Burma, and in Travancore. It has also been discovered in Sikkim, where a graphite vein, averaging about 13 inches in thickness, was found during the prospecting operations conducted by Messrs. Burn and Company at about half a mile to the north of the road from Tsuntang to Lachen. The quality of the mineral is said to be good, large bulk samples having given a return of 93 per cent. of graphite. Other veins of graphite are known to occur in the area, but have not been examined in detail.[2] It is also found in Ajmer-Merwara (Rajputana),[3] and that district (1915 to 1920)

[1] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 102, (1904).
[2] According to a report by C. Wilkinson, communicated by the late Mr. A. Whyte of Raniganj.
[3] *See* A. M. Heron, *Trans. Min. Geol. Inst. Ind.*, Vol. XXIX, p. 353, (1935).

and Kalahandi and Patna in Orissa were responsible for a slight revival of the industry, which had died out in the year 1912. That industry has, however, again become dormant. During the period under review there has been an output of 39 tons valued at Rs. 1,116 (£87) from Ajmer-Merwara in 1929 and of 6·5 and 5 tons in 1931 and 1932 respectively from the Kistna district, Madras.

The graphite deposits of Travancore occur under conditions similar to those of Ceylon, whose rocks are but a continuation of the charnockite series and associated rocks of South India. The Ceylon graphite has been made the subject of an elaborate study by E. Weinschenk, who regards it as of igneous origin,[1] a conclusion in agreement with its occurrence in South India.[2] Small quantities of graphite have been extracted in Godavari and Vizagapatam, but formerly practically the whole of the Indian production came from Travancore, where the average output used to be about 13,000 tons annually. Owing to difficulty of working at increased depths, however, the mines were no longer found to pay and were shut down in 1912. In 1915, the impossibility of obtaining graphite from abroad threw India on to her own resources; an indigenous supply again became necessary, various known deposits were opened up and there was an output of 1,318 tons in 1916. Most of this came from Rajputana and, like the Kalahandi material, is derived from raw material of comparatively low grade.

Production.

The occurrence of graphite in khondalite deserves further notice. One of the most prominent components of the rock formations in the Eastern Ghats facies of rocks found in Orissa and the Madras Presidency is the khondalite series, khondalite being a schist composed of quartz, sillimanite, garnet, and graphite. It is not surprising, therefore, to learn that deposits of graphite of possible economic value—bands, veins and pockets—are sometimes found in association with this series. Owing possibly to the comparatively inaccessible and undeveloped character of this part of India, only a few deposits of graphite of very moderate value have, however, hitherto been discovered—in the States of Kalahandi and Patna, with recorded occurrences in the States of Athmallik and Sonpur, but other discoveries must be expected in the future when this tract

[1] Die Graphitlagerstätten der Insel Ceylon, *Abhand, d.k. Bayer, Akad.*, 1901, XXI, pp. 279-335.

[2] T. H. Holland, 'The Charnockite Series', *Mem. Geol. Surv. Ind.*, XXVIII, p. 126, (1900); and 'The Sivamalai Series', *op. cit.*, XXX, p. 174, (1901).

becomes better known. In Kalahandi State, graphite deposits have been found at two localities. At Koladi Ghat, bands 12 to 20 inches thick have been met with in clay resulting from the decomposition of khondalite, whilst at Densurgi bands of calcareous graphite occur in a decomposed gneiss, which in its fresh condition was probably a garnet-graphite-biotite-gneiss.

Graphite deposits have also been found at Dharamgarh and Domaipali in Patna State in graphite-schists associated with garnetiferous gneissose schists, doubtless a variety of the khondalite series. Assays of specimens and samples from Densurgi in Kalahandi and Dharamgarh, Marna (2 miles west of Patna) and Dundel in Patna State have been made with the following results:

	Densurgi.		Dharamgarh.		Marna.		Dundel.	
	1	2	3	4	5	6	7	8
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Sulphur	..	..	trace.	..	..	..	..	..
Moisture	..	1·12	0·38	0·42	0·79	0·14	0·23	1·23
Volatile matter	6·33	3·89	0·38	0 89	0·61	2·08	2·15	3·58
Carbon dioxide	..	..	10·60	12 14	..	..	..	..
Fixed carbon (diff.)	65·22	63·12	40·95	37·00	79·91	69 67	63·70	54·73
Ash	31·21	31·87	47·69	49·55	16·69	28·11	33·87	40·47

Sample 1 was assayed in the laboratory of the Geological Survey of India, and the remainder at the Imperial Institute. The latter samples were forwarded to an expert for report on their commercial value. He reported that they had not enough binding quality to be used for the manufacture of crucibles, but that, if obtained sufficiently pure, such graphite might be used for crucibles which were subjected to one heating and then ground up and remodelled. During the war, however, the difficulty of obtaining graphite from abroad led to the opening up of the Kalahandi deposits by the Indian Graphite Company (Messrs. Bird & Co.). The product was transported to Bisra for treatment and there picked by hand and sorted into needle (crystalline) and amorphous varieties, crushed and sieved, and put on the market as foundry graphite in two grades, the needle variety being used for the production of the higher grade. The output from Orissa States rose from 16 tons in 1915, to 252 tons in 1916, and fell to 122 tons in 1919, and 60 tons in 1920, since when

there has been no production from Orissa. The reason for the decline was the high cost of transport of the raw graphite from the mines in Kalahandi and Patna States to the refinery, more than 120 miles of which had to be traversed by bullock cart. However, the new Raipur-Vizianagram railway line which is now opened for traffic passes within 15 miles of the deposits, so that a revival of the industry in this area may be expected.

Graphite has also been recorded from Durdura in Sonpur State and from Athmallik State. No details are known as to the mode of occurrence at these two localities, but it is significant that the khondalite series is prominently represented in Athmallik and probably in eastern Sonpur.

The earlier outputs from Godavary and Vizagapatam were presumably also from the khondalite series.

According to Mr. V. S. Sambasiva Iyer in a recent communication, graphite occurs in some quantity in graphitic gneisses near Kurunjakulam in the Kuruvikutam zamindari of Sankaranayinarkovil *taluk* of Tinnevelly district.

In Chota Nagpur, graphite has been recorded from the Palamau and Monghyr districts in graphite schists and gneisses, but none of these occurrences has yet proved to be of economic value. A small production of graphite was reported from the Betul district of the Central Provinces in 1920 and 1921.

Ilmenite.

[L. L. Fermor.]

Ilmenite, titaniferous iron-ore, occurs as a common accessory mineral in many of the crystalline rocks of Peninsular India. It is occasionally found in masses of some size in the mica pegmatites of Bihar and Orissa. It accompanies wolfram at Degana in Rajputana. Ilmenite is plentiful in concentrates from Tavoy and other parts of Burma. About 3 miles south of Kishengarh in Rajputana large crystals of ilmenite, 2 to 3 inches in diameter, are found associated with clear calcite crystals forming a broad vein in the granitoid gneiss. This ore was at one time smelted in the local native furnaces.

But it is in the black sands of the Travancore coast that ilmenite occurs most plentifully in India. The production of Travancore during the previous quinquennium progressed by leaps and bounds, and by 1927 India had become the largest producer of ilmenite in

the world; and the output during the previous quinquennium rose from 641 tons in 1924 to 25,307 tons in 1928. During the present five years the production has increased further to 52,980 tons in 1933, with an annual average of 38,329 tons valued at £44,741.

TABLE 46.—*Production of Ilmenite in Travancore during the years 1929 to 1933.*

Year.	Tons.	*Value.*
		£
1929	23,670	*28,602*
1930	28,776	*32,993*
1931	36,166	*41,991*
1932	50,053	*58,134*
1933	52,980	(*a*) *61,987*

(*a*) Estimated on the basis of the average value of the preceding four years.

The Travancore black sands—usually called monazite sands until the decline of the gas mantle industry rendered their content of that mineral relatively unimportant—have been described by G. H. Tipper.[1]

They occur sporadically along the shore line from Nindikarai, north of Quilon, on the west coast to Cape Comorin, and then round the east coast to Liparum, a distance of about a hundred miles. Tipper ascribes their peculiar accumulation to wave sorting on a beach of abnormal slope during quiescent north-east monsoon periods. Dunes, too, have frequently been formed by the action of the wind on the sun-dried sands of the beach. The principal firm now working the deposits is the Travancore Minerals Company, Limited, whose factory is at Manavalakurichi (8° 8′; 77° 18′). The beach sand from which ilmenite is being extracted is said to contain as much as 70 per cent. of that mineral. The sand is fairly hard-packed, but damp, and is worked to a depth of about eight feet. It is dug out by hand into baskets and dried in the sun. It is then treated by screens, concentrating tables and magnetic separators, and thus freed from zircon, monazite, rutile, garnet and several

[1] *Rec. Geol. Surv. Ind.*, XLIV, p. 186, (1914).

other minerals. The ilmenite is taken by road five miles west-north-west to Kolachel, where it is loaded into lighters and delivered to ships anchored off the coast.

The chief use of ilmenite is in the manufacture of white paints consisting of titanium dioxide, either pure or, more usually, in conjunction with zinc oxide, barium sulphate, calcium sulphate or lithophone. The opacity or hiding power of titanium dioxide is very high; it is not poisonous and it has great resistance to corrosion. For a comparison of its properties with those of other white pigments reference may be made to papers by A. W. Hixson and W.W. Plechner[1] and by C. S. Fox.[2] Other uses for titanium are in the manufacture of the alloys ferro-titanium and ferro-carbon-titanium and of the carbide used as a super-hard cutting agent.[3]

Iron.

[A. M. HERON.]

Production.

Bihar and Orissa and Mysore are the only parts of India in which iron-ore was mined during the period under review for the production of iron and steel by European methods. In Burma a considerable amount of ore, limonite and hæmatite, is won by the Burma Corporation, Ltd., at Wetwun, near Maymyo, but this is entirely for use as a flux in the lead smelting operations at Namtu. Table 48 shows the annual raising of iron-ore in Bihar and Orissa during the last fifteen years. The raisings suddenly increased in 1911 by nearly 300,000 tons, the total rising from 42,653 tons in the preceding year to 342,342 tons in 1911. This was due to the operations of the Tata Iron and Steel Company, Ltd., the first stage of whose works at Jamshedpur (formerly known as Sakchi) was completed towards the end of that year; large quantities of iron-ore were therefore raised from their Gurmaisini[4] deposits in Mayurbhanj State with a view to bringing the blast furnaces into operation. For the period 1911 to 1918 the yearly raisings of iron-ore in India were of the same order of magnitude, but during the last fifteen years there has been a big increase in the yearly raisings to a maximum of 2,337,344 tons in 1929,

[1] *Chem. Met. Eng.*, Vol. XXXVI, p. 76, (1929).
[2] *Trans. Min. Geol. Inst. Ind.*, Vol. XX, p. 216, (1926).
[3] 'Mineral Industry during 1933', p. 624.
[4] 'Gurumahisani', 'Gurumaishini', 'Gorumahisani', and other spellings.

TABLE 47.—*Production and value of Iron-ore produced in India during the years 1929 to 1933.*

	1929		1930		1931		1932		1933	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Bihar and Orissa	2,337,344	*61,91,309*	1,783,742	*46,29,600*	1,599,386	*40,78,916*	1,744,247	*38,71,401*	1,154,396	*22,11,875*
Burma	46,140	(a) *1,54,560*	33,458	(a) *1,33,832*	1,886	(a) *7,544*	6,560	(a) *26,240*	36,293	(a) *1,45,172*
Central Provincs	715	*2,145*	925	*2,775*	763	*2,289*	803	*2,409*	777	*2,331*
Madras	..	..	..	..	4,329	*2,597*	4,496	*4,456*	2,118	*1,291*
Mysore	(b)45,937	(b)*1,20,278*	31,499	*1,06,320*	18,517	*67,391*	4,394	*15,263*	35,041	*1,37,245*
TOTAL .	(b) **2,430,136**	(b) *64,98,292*	**1,849,624**	*48,72,527*	**1,624,881**	*41,58,737*	**1,760,500**	*39,19,769*	**1,228,625**	*24,97,914*
Total value in Sterling .	..	(b) *£484,947*	..	*£360,928*	..	*£308,055*	..	*£294,720*	..	*£187,813*
		(£1 = Rs. 13·4)		(£1 = Rs. 13·5)		(£1 = Rs. 13·5)		(£1 = Rs. 13·3)		(£1 = Rs. 13·3)

(a) Estimated.
(b) Revised.

TABLE 48.—*Iron-ore raised in Bihar and Orissa during the years 1919 to 1933.*

Year.	Singh-bhum.	Sambal-pur.	Mayur-bhanj.	Keon-jhar.	Puri.	TOTAL QUANTITY.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1919	104,728	945	423,599	..	..	**529,272**
1920	118,008	1,010	403,359	..	..	**517,377**
1921	237,173	707	651,495	..	..	**889,465**
1922	215,746	798	378,134	..	..	**594,678**
1923	218,584	632	507,225	..	..	**726,441**
1924	305,238	654	996,920	..	..	**1,302,812**
1925	477,580	708	957,275	..	..	**1,435,558**
1926	552,079	569	1,041,929	..	..	**1,594,577**
1927	1,007,037	561	692,137	36,325	..	**1,736,060**
1928	1,131,746	21	683,493	141,361	..	**1,956,621**
1929	1,390,245	21	759,875	187,203	..	**2,337,344**
1930	1,099,435	6	659,302	24,909	..	**1,783,742**
1931	588,290	..	901,246	109,841	9	**1,599,386**
1932	666,874	7	891,193	186,173	..	**1,744,247**
1933	616,946	4	341,502	195,944	..	**1,154,396**
Average .	*581,647*	*448*	*685,918*	*125,965* (7 years)	*9* (1 year)	*1,326,798*

falling, however, to half that in 1933. In the last quinquennial review it was stated that the production of pig-iron in Mysore was commenced in January, 1923 and that the daily output has been between 40 and 75 tons. The average quantity of iron-ore raised annually during the previous quinquennium was 29,084 tons and in that under review was 26,827 tons the output being as high as 56,218 tons in 1925, and as low as 4,394 tons in 1932.

In the quinquennial review for 1919-1923 it was noted that the Indian Iron and Steel Company, Ltd., were obtaining iron-ore from the Central Provinces as they were unable to get sufficient ore from their Gua mines in Singhbhum, mainly owing to transport difficulties. These difficulties were overcome in 1924, and the raising of iron-ore in the Central Provinces dropped from 68,361 tons in 1924, to 1,037 tons in 1925; it has since decreased to 777 tons in 1933, the whole of this total being used in the indigenous smelting industry. In the cold weather of 1926-27 the Tata Iron and Steel Company, Ltd., commenced mining ore at their new mine at Noamundi in

Singhbhum, 156,425 tons of ore being mined. In the following year the output from this mine was 507,580 tons. (*See* Table on p. 140.)

The iron-ore raised in Sambalpur by the local *lohars* dropped suddenly from 561 tons in 1927, to 21 tons in 1928, and to 4 tons in 1933.

Since 1927, iron-ore has been mined by Messrs. Bird and Company, Ltd., in Keonjhar State, the output being taken by the Indian Iron and Steel Co., Ltd.

General character of the iron-smelting industry.

The pages of the *Records* and *Memoirs* of the Geological Survey for the past seventy years contain ample evidence of the attention that has been paid to the iron-ores of India, but it is only within the last 25 years that any successful attempt has been made to establish an iron and steel industry on modern lines. On the other hand, iron-smelting was at one time a wide-spread industry in India, and there is hardly a district away from the great alluvial tracts of the Indus. Ganges, and Brahmaputra, in which slag-heaps are not found, for the primitive iron-smelter finds no difficulty in obtaining sufficient supplies of ore from deposits that no European iron-master would regard as worth his serious consideration. Sometimes he will break up small friable bits of quartz-iron-ore schist, concentrating the ore by winnowing the crushed materials in the wind or by washing in a stream; sometimes he is content with ferruginous laterites, or even with the small granules formed by the concentration of the rusty cement in ancient sandstones. In ancient times the people of India seem to have acquired a fame for metallurgical skill, and the reputation of the famous *wootz* steel, which was certainly made in India long before the Christian era, has probably contributed to the general impression that the country is rich in iron-ore of a high-class type. It is true that throughout the Peninsula, which is so largely occupied by ancient crystalline rocks, quartz-hæmatite and quartz-magnetite schists are very common in the Dharwarian system, the system of rocks that, lithologically as well as stratigraphically, corresponds approximately to the Lower Huronian of America. But most of these occurrences consist of quartz and iron-ore so intimately blended that only a highly siliceous ore of a low grade can be obtained without artificial concentration. These occurrences of quartz-iron-ore schist are so common in India that newly recorded instances are generally passed over as matters of very little immediate

economic interest. For a number of years, however, ore-bodies of great size and richness have been recognised in a belt running through the southern districts of Bihar and Orissa and constituting what is one of the most important groups of iron-ore deposits of the world.

Attempts to introduce European processes.

Earlier attempts to introduce European processes for the manufacture of pig-iron and steel in India, had been such conspicuous failures that there was naturally some hesitation in reposing confidence in the project launched by Messrs. Tata, Sons and Company. Perhaps the earliest attempt to introduce European processes was due to the enthusiasm of Mr. Josiah Marshall Heath of the Madras Civil Service, who, having resigned the service of the East India Company, obtained the exclusive privilege of manufacturing iron on a large scale in the Madras Presidency. In 1830 trial works were erected at Porto Novo in the South Arcot district, and were maintained by subsequent financial assistance from the East India Company. The business was taken over in 1833 by the Porto Novo Steel and Iron Company, and additional works were started at Beypur on the Malabar coast. Various concessions were granted to Mr. Heath and to the succeeding iron company, but in spite of these the undertaking proved to be a failure. In 1853, a new association, known as the East India Iron Company, was started with a capital of £400,000. This company obtained various concessions from Government, and erected two blast furnaces, one in the South Arcot district and another on the Cauvery river, in the Coimbatore district. These furnaces were stopped in 1858, whilst operations at Porto Novo ceased in 1866, and at Beypur in 1867. Other attempts to introduce European processes have been made in the Birbhum district of Bengal and at Kaladhungi in Kumaon.

TABLE 49.—*Production of Pig-Iron in India during the years 1929 to 1933.*

Company.	1929.	1930.	1931.	1932.	1933.
	Tons.	Tons.	Tons.	Tons.	Tons.
Tata Iron & Steel Co., Ltd.	722,950	695,923	799,545	699,931	793,953
Indian Iron & Steel Co., Ltd.	451,059	354,772	243,214	198,700	249,079
Mysore Iron Works	21,452	20,668	15,577	14,683	14,805
Bengal Iron Co., Ltd.	196,090	103,929	*Nil.*	*Nil.*	*Nil.*
TOTAL	**1,391,551**	**1,175,292**	**1,058,336**	**913,314**	**1,057,837**

TABLE 50.—*Production of Steel (including steel rails) by the Tata Iron & Steel Co., Ltd.*

Year.	Tons.
1929	410,923
1930	427,035
1931	439,134
1932	430,333
1933	505,429

Bengal Iron Company, Limited.[1]

The first scheme which proved to be a financial success is that now in operation at Kulti, near Barakar in Bengal. The Barakar ironworks passed through various vicissitudes of fortune, and showed no signs of financial success until the agency was taken over by Messrs. Martin & Company in 1889, when the Bengal Iron and Steel Company was formed and the plant completely remodelled. During 1919, the Company changed its title to the present form 'The Bengal Iron Company, Limited' and the change was accompanied by a substantial increase in the capital. A further change took place in 1932 when the Managing Agents were replaced by the Company's own office and organisation in Calcutta. Of the four blast furnaces at Kulti two worked during 1929, one during 1930 and none have worked since that year. Pig-iron only was manufactured in 1929 and 1930 the output being :—

	Tons.
1929	196,090
1930	103,929

The following are the average analyses of the grades of pig-iron produced :—

—	Grade No. 1.	Grade No. 2.	Grade No. 3.	Grade No. 4.
	Per cent.	Per cent.	Per cent.	Per cent.
Graphitic carbon	3·60	3·45	3·10	3·00
Combined carbon	0·20	0·25	0·35	0·45
Silicon	2·5 to 3·0	2·0 to 2·5	1·5 to 2·0	1·0 [illegible] 1·5
Phosphorus	·25	·25	·25	[illegible]
Manganese	1·0 to 1·5	1·0 to 1·5	1·0 to 1·5	0·9 to 1·25
Sulphur	0·04 max.	0·05 max.	0·06 max.	0·07 max.

[1] Information kindly furnished by Messrs. The Bengal Iron Co., Ltd.

Pig-iron to the above analyses but having phosphorus up to 1·5 per cent. was also produced when required.

The blowing engines comprise five Parson's turbo-blowers, one of 18,000 cubic feet per minute up to 7 lbs. per square inch pressure, one of 25,000 cubic feet at 7½ lbs. pressure, one of 50,000 cubic feet at 7½ lbs. pressure, one of 30,000 cubic feet at 10 lbs. pressure, and one of 40,000 cubic feet at 18 lbs. pressure.

The iron foundries cover an area of about 200,000 square feet and comprise pipe foundries, sleeper foundries, and a foundry for general and special castings, the latter being specially equipped to deal with heavy castings. A large well-equipped machine shop disposes of the works' repairs and machines the larger or more intricate castings. The bulk of the castings are, however, machined in a special shop attached to the foundry. The outturn of iron castings during the period under review was as follows :—

	Tons.
1929	42,227
1930	43,703
1931	61,368
1932	22,308
1933	42,239

The coke used is made at Kulti in four batteries, each of 34 ovens. Three are of Messrs. Simon Carves regenerative type and one waste heat The output of coke for the last five years has been as follows:—

	Tons.
1929	234,612
1930	172,946
1931	56,021
1932	82,965
1933	80,547

Tar and sulphate of ammonia are recovered from the waste gases, the necessary sulphuric acid being made also at the Company's works at Kulti.

The Company's coal supply is obtained from their own collieries, Ramnagar in the Raniganj coalfield, and Noonodih and Jeetpur collieries in the Jharia coalfield. Both collieries are fully equipped and capable of supplying 40,000 tons of excellent coking coal monthly to ironworks. All coal is mechanically screened and sized.

The following are the average analyses as certified by the Indian Coal Grading Board :—

——	Noonodih-Jitpur 17 seam.	Noonodih-Jitpur 18 seam.	Ramnagar (Ramnagar seam).	Ramnagar (Laikdih seam).
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	2·10	1·80	1·52	1·20
Ash	11·80	11·90	12·97	12·43
Volatiles	28·00	28·80	25·53	26·90
Fixed Carbon . . .	60·20	59·30	61·50	60·57
Calories	7,344	7,209	7,262	7,411

The Company has also large reserves of coal in other areas adjacent to the works, not yet developed, largely caking coals.

Noonodih-Jeetpur collieries are served by the Bengal Nagpur railway, and Ramnagar by the East Indian railway and the Bengal Nagpur railway.

The limestone used as a flux is raw, and is obtained from the Bisra Lime Company and also from contractors at Paraghat and Baraduar on the Bengal Nagpur railway. The average analysis of the stone is as follows :—

	Per cent.
Calcium carbonate	95·80
Silica	2·70
Ferric oxide and alumina	0·80
Magnesium carbonate	2·25

The site of the Barakar ironworks was originally chosen on account of the proximity of both coal and ore deposits. The outcrop of Ironstone Shales, between the coal-bearing Barakar and Raniganj series, stretches east and west from the works, and for many years the clay-ironstone nodules from this formation constituted the only supply of ore used in the blast furnaces. The use of ore from this source has been abandoned for some years in favour of the richer ore from the company's deposits in the Kolhan Estate, Singhbhum. The principal deposits are known as Pansira Buru, on which the Pansira quarries are opened up, and Buda Buru, on which the Maclellan quarries are being worked. These are situated

respectively twelve and eight miles south-east of the Manharpur station of the Bengal Nagpur railway. The total quantity of ore in Pansira Buru has been estimated at 10 million tons, whilst that in the Buda Buru area is tremendous and has been roughly estimated at over 150 million tons. The ore is generally a high-grade hæmatite with an average analysis of :—

	Per cent.
Iron	64·0
Silica	2·10
Lime	0·15
Alumina	1·25
Magnesia	0·18
Manganese oxide	0·05
Sulphur	0·002
Phosphorus	0·05

A 2-foot-6-inch railway line has been constructed by the Bengal Iron Company from Manharpur to Pansira, with a branch through the Ankua valley to the foot of Buda Buru. An aerial ropeway, with a capacity of 40 tons hourly, transports the ore from the top of Pansira Buru (hill) to a bin at the foot, from which it is automatically loaded into the railway wagons. A gravity incline, with a capacity of 60 tons hourly, transports the ore likewise from a spur of Buda Buru to the railway at the foot. The following table shows the quantity of ore used during the period under review :—

	Iron-ore. Tons.
1929	379,955
1930	380,034
1931	177,320
1932	23,738
1933	*Nil.*

The average number of persons employed daily at the Kulti works was as follows :—

1929	7,264
1930	5,947
1931	4,225
1932	2,173
1933	2,851

Indian Iron and Steel Company, Limited.[1]

The Indian Iron and Steel Co., Ltd., was floated under the managing agency of Messrs. Burn & Company with a capital of Rs. 3,00,00,000 (since reduced to Rs. 1,50,00,000) on the 11th March, 1918, for the purpose of manufacturing pig-iron, by-product coke, coal tar products, sulphate of ammonia, and sulphuric acid. The Company possesses its own iron-ore, coal and limestone mines, within easy reach of the works, which are situated in the fork made by the Bengal Nagpur and the East Indian railway companies at their junction at Asansol, 132 miles north-west of Calcutta.

Blast furnace plant.

The works consist of two 800-ton, mechanically charged modern furnaces. The tunnel system is employed for the handling of raw material to the furnace and 75-ton capacity ladles are used for conveying the hot metal to two double-strand pig machines or to the sand-cast pig bed. All pig-iron is handled by magnets.

The blowing plant installed consists of two C. A. Parsons' high-pressure full-reaction type, steam turbo-blowers, each with an economical output of 40,000 cubic feet of free air per minute at a pressure of 14 lbs., and a maximum output of 36,000 cubic feet of free air per minute at a pressure of 23·5 lbs. Two large Parsons' turbo-blowers have also been added, each with an output of 50,000 cubic feet of air at 18 lbs. pressure, a maximum rating of 60,000 cubic feet at 23 lbs. and capable of blowing 48,000 cubic feet at a maximum pressure of 30 lbs.

Six blast furnace gas-fired Babcock and Wilcox boilers, each having 4,510 square feet of heating surface, and constructed for a working pressure of 200 lbs. per square inch, and capable of an evaporation of 75,000 lbs. of water per hour, serve the blowing plant.

Coke oven and by-product plant.

The coke oven and by-product plant consists of two batteries, each of eighty Simon-Carves, horizontal-flue, waste-heat ovens capable of producing 1,000 tons of coke per day. A battery of forty Simon-Carves, underjet ovens, capable of producing 450 tons of coke per day, has also just been put into operation. The coal-charging cars and the combined leveller and coke rams employed are electrically driven. The coke is discharged on to inclined coke

[1] Information kindly furnished by Messrs. The Indian Iron & Steel Company, Limited.

cars which are hauled by electric locomotives to central quenching stations. When quenched, the coke is discharged on to an inclined coke bench and fed by means of a belt conveyor over a screening plant and discharged direct into the blast furnace bunkers.

The direct recovery system is employed for the recovery of by-products, and a sulphuric acid plant capable of producing 18 tons of 80 per cent. acid per day from natural sulphur has been installed.

Electric power plant.

Two 3,000 kw. turbo alternator sets, with the Westinghouse Rateau high-pressure type of turbine, driving the Westinghouse alternating current type of generator, are in operation and an auxiliary 150 kw. direct current lighting set has also been installed to provide for works and bungalow lighting, should the large sets not be running. The necessary steam for driving the turbines is obtained from a battery of ten Babcock and Wilcox patent water tube boilers arranged for firing with waste heat from the coke ovens and with surplus gas. Each boiler has a heating surface of 5,246 square feet and is constructed for a working pressure of 200 lbs. per square inch.

Water supply.

The necessary circulating water for the turbo-blowers, turbo-alternator, blast furnace plant and the works is obtained from a large reservoir on the works area containing approximately 300,000,000 gallons of water; the make-up water for the reservoir is pumped from the Damodar river at a distance of 2½ miles from the works by two electric pumps, each capable of pumping 60,000 gallons per hour.

The whole of the above-mentioned plant is in full operation and a ready market is being found for all the company's products.

Ore mines.

The company's ore mines are situated at Gua in the Kolhan Government Estate, Singhbhum. The Bengal Nagpur railway have a branch line terminating at Gua which is fully capable of taking all the ore from these mines. The mines are now fully developed, and are capable of an output of over 60,000 tons per month.

A ropeway having a capacity of 120 tons per hour has now been in use some years, and is giving every satisfaction. Feeding into the bunker at the top of the ropeway are two sel -acting inclines, one being on the endless rope principle. The ordinary two-ton mine tubs are clipped to the rope at intervals, the descending loads drawing the empty tubs up. The speed is controlled by brakes.

An output of 800 tons daily is obtained from this incline. The second incline is operated by eight-ton skips. On this incline the gradients are very severe, and the brakedrums are controlled by eight double-post brakes. The output from this incline will eventually be 1,000 tons daily. A third incline is in use. The output from here will be from 600—800 tons daily.

At the bottom of the ropeway the buckets are emptied into a 2,000-ton capacity bunker. The hopper-wagons supplied by the railway are loaded direct from this bunker at the rate of 10 tons per minute.

An endless rope self-acting incline, $1\frac{1}{2}$ miles long, bringing ore from the mines 2,800 feet above sea-level down to the railway at 1,480 feet was started in February, 1929. The tubs from this incline are emptied into a crusher by means of a power-driven tippler, the tubs being returned to the incline by means of an automatic traverser. The ore is reduced to 2-inch cube size and then emptied direct into the hopper wagons. The output from this incline is 800 tons daily.

In the Jhiling Buru area a light railway brings ore mined from the reef at the lower level, the tubs being emptied direct into the wagons. There is also an incline operating with skips bringing ore from the top of the hill. The ore is brought by means of a light railway from the quarries to the bunker at the top of the incline. It is then loaded into a skip, which on arrival at the bottom of the incline is emptied into a crusher, where the ore is reduced to $2\frac{1}{2}$-inch cube. The output from this area is expected to be 1,000 tons daily.

The power plant consists of a 625 kw., C. A. Parson's turbine. This drives the various compressors and pumps on the mines. A new power-house is at present being built. Nearly all drilling on the mines is done by jack-hammers, driven by means of three electrically driven compressors.

A large labour force has been induced to live on the mines, where suitable accommodation has been provided. The drinking water for the labour, and the feed-water for the locomotives on the ropeway section is supplied by means of a 7,000-gallon per hour turbo-pump, pumping up from springs in the valley 1,000 feet below. Another spring on the other side of the hill supplies water to the village.

Tata Iron and Steel Company, Limited.[1]

The works of the Tata Iron and Steel Co., Ltd., are situated at Jamshedpur, two miles from Tatanagar station on the Bengal Nagpur railway, 155 miles west of Calcutta. Originally two blast furnaces with a daily capacity of 250 tons of pig-iron each, were installed, but these have been added to and reconstructed, so that now there are five, of which the two largest are capable of producing 1,200 and 900 tons of pig daily, two of 750 tons and one of 250 tons, a total possible annual output of about a million tons of pig. The largest blowing engines have a capacity of 120,000 cubic feet of air per minute. About three-quarters of the iron produced by Tata's is used in the manufacture of steel, being hauled in a molten state in 60-ton ladles, by locomotives, to the open-hearth and Duplex steel-making plants.

The power-houses produce 37,500 kilowatts, and provide not only for the plant itself but for the public utility services of the town as well and for other factories, such as the Tinplate Company and the Indian Cable Company. The boilers are fired by waste gases from the blast furnaces. The coking plant consists of 180 Coppee ovens in four batteries (the earliest, and now partly dismantled), 150 Wilputte ovens in three batteries, and 50 Koppers ovens in one battery. Tar, ammonia and fuel gas are recovered from the Koppers and Wilputte plants, the ammonia being converted into sulphate by means of sulphuric acid made in the works from imported sulphur. The coke ovens are filled, levelled and discharged by electrically-driven rams, and the hot coke is discharged into electrically-driven cars which pass under sprays of water to quench it. It is then mechanically charged from bins into the blast furnaces, with ore and limestone, the furnaces being fitted with revolving distributors.

The air for the blast furnaces is heated in large brickwork stoves which are heated by burning the waste gases that leave the top of the furnaces.

The open-hearth plant consists of three 75-ton and four 60-ton furnaces with a combined capacity of 1,000 tons of steel daily, and the Duplex plant is three 200-ton basic-lined tilting furnaces, fed from three 25-ton acid-lined Bessemer converters, capable of producing jointly 2,000 tons of steel daily.

[1] Information kindly furnished by Messrs. Tata Iron & Steel Company, Limited.

In the open-hearth process the charge consists of about equal parts of molten pig-iron, which is stored in a 400-ton mixer, and steel scrap from the rolling mills. The open-hearth furnaces are heated by producer-gas, and lime and iron-ore are added to remove impurities and to bring the steel to the composition required. It is then cast into 5-ton ingots.

In the Duplex process molten pig is charged from a 1,000-ton mixer into the Bessemer converters, 24 tons at a time, in which air is blown through it to remove part of the impurities. It is then transferred to the tilting furnaces until about 130 tons is accumulated, undergoing further purification and adjustment to the required composition. This charge is then poured into a 130-ton ladle and cast into 5-ton ingots. After the ingots have solidified the moulds are removed and the ingots are stored in gas-heated soaking pits where they are brought to a uniform temperature for rolling.

The Duplex process does not consume the scrap which is left over from the rolling of ingots made by it, whereas the open-hearth takes more scrap than results from the rolling of its own ingots. The combination of the two makes the Tata works almost self-contained.

The rolling mill plant consists of a 40-inch blooming mill in which 3- and 5-ton ingots are reduced to blooms and slabs of varying dimensions; 24-inch and 18-inch continuous mills in which the blooms from the blooming mill are rolled down into billets, bars, sleeper-plates and flats; a 35-inch roughing mill taking large blooms for heavy structural sections; a 28-inch mill for rails, sections, beams, channels and angles; a 12-inch merchant mill for rounds, squares, flats, angles, tees and channels; a 96-inch plate mill for rolling plates up to 7 feet wide and from $\frac{1}{8}$ inch to $1\frac{1}{4}$ inches thick, and a group of sheet mills with annealing furnaces, pickling and galvanising equipment, with an annual production of 110,000 tons of galvanised and black sheets. All the above are electrically driven and the original steam-driven mills have been largely replaced by electrically-driven ones. The pressed-steel sleeper plant can turn out 20,000 tons of steel sleepers annually. The combined capacity of all the Tata mills is about 700,000 tons of steel annually.

The Tata Iron & Steel Company possesses rich iron-ore deposits in the Kolhan Government Estate of the Singhbhum district, Bihar and Orissa, and in Keonjhar State, but prior to 1926 (when Noamundi iron mine in the Kolhan was opened) practically the whole of the supplies of iron-ore came from their deposits in Mayurbhanj State, which are nearest to the site of the works and to which the Bengal Nagpur Railway Company has built a branch line about 56 miles in length.

Iron-ores of Mayurbhanj State.

The occurrence of valuable iron-ore deposits in Mayurbhanj was first noticed by P. N. Bose, who mentioned the following occurrences :—

(*a*) Bamanghatti sub-division :—

(1) Gurumahisani Hill, over an area of 8 square miles.

(2) Near Bandgaon in Saranda-pir.

(3) Sulaipat-Badampahar range from Kondadera to Jaidhanposi, a distance of some 12 miles.

(*b*) Panchpir sub-division :—

At several places from Kamdabedi and Kantikna to Thakurmunda, a distance of 25 miles.

(*c*) Mayurbhanj proper :—

Simlipahar range, and the submontane tract to the east (Gurguria, Kendua and Baldia).

Subsequently, on the possibility of these ores being suitable for the proposed iron and steel works, they were re-examined by Messrs. C. P. Perin and C. M. Weld, who arranged for detailed prospecting operations after securing prospecting rights from the Maharajah. A subsequent examination of the ground by Mr. W. Selkirk having demonstrated the existence of sufficient ore to warrant operations on a large scale, a lease was granted to the company over 12 square miles.

Prospecting operations determined the existence of over a dozen considerable deposits of high-grade ore in the more accessible parts of the State (*see* fig. 10). Of these deposits three, namely, Gurumahisani, Okampad (Sulaipat), and Badampahar, so far overshadow the others that reference will be made in detail to them alone. The ores are of the same type as those of Singhbhum and Orissa described

by Mr. H. Cecil Jones.[1] The 'hæmatite breccia' mentioned by Mr. Jones is rare in the Mayurbhanj deposits, but the other types are all present, including the shaly laminated ore and the powdery 'micaceous hæmatite.' Deposits of these two types have been exposed *in situ* in the workings at Gurumahisani. Small deposits of magnetite are found at Sulaipat and Badampahar.

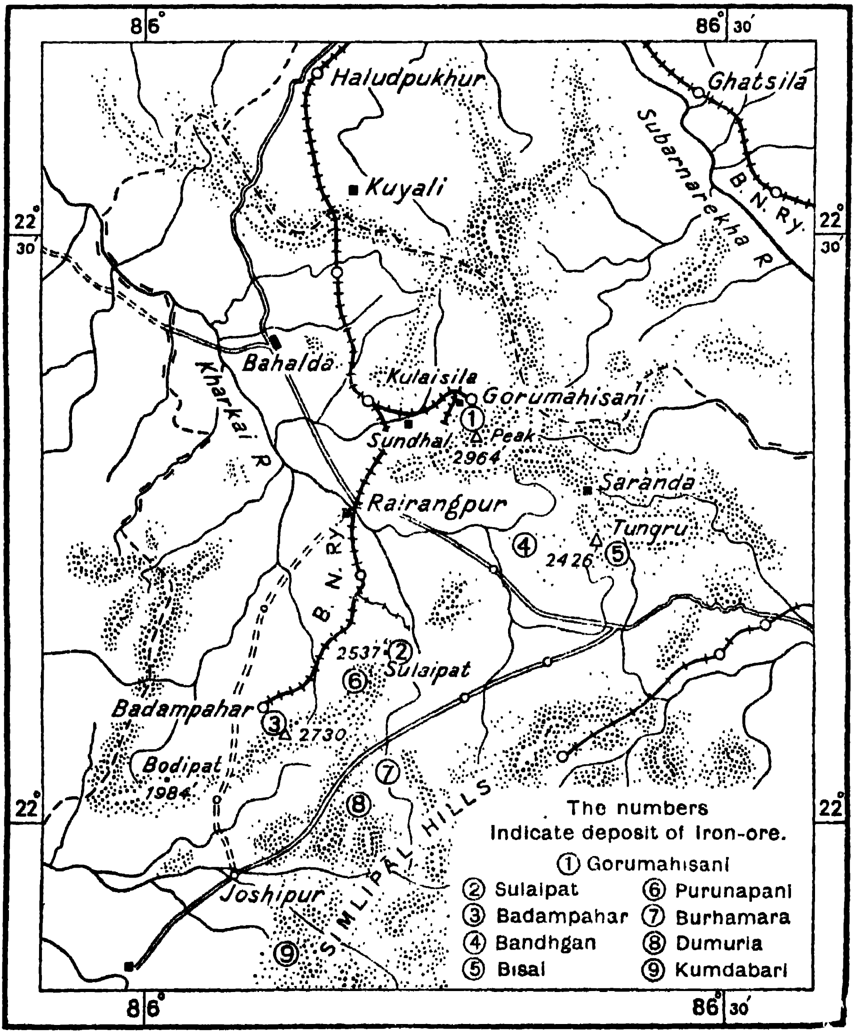

FIG. 10.—*Map showing position of the Mayurbhanj iron-ore deposits. Scale 1 inch = 12 miles.*

[1] *Rec. Geol. Surv. Ind.*, LIV, pp. 203-214, (1923); *Mem. Geol. Surv. Ind.*, LXIII, pt. 2, pp. 230-299, (1934).

(I) Gurumahisani.

The Gurumahisani hill-mass, with its three prominent peaks, the highest rising to an elevation of 3,000 feet above sea level, and its numerous flanks and spurs, forms a conspicuous feature in the topography of the northern part of the State. The large quantity of iron-ore found at this place and its accessible position combined to make it the first point of attack. In 1914-15 a careful estimate of the contents of the Mayurbhanj deposits was made by Mr. E. Curnow, and Gurumahisani was proved to contain 9,800,000 tons of ore. Since that date about 7 million tons have been extracted, but new discoveries of rich float deposits, and also deposits of ore *in situ* previously concealed by float ore, have increased the estimated reserves. The quantity of ore still remaining at Gurumahisani probably amounts to about six million tons.

Up to the end of 1928, the whole of the ore won at Gurumahisani was float ore. The first deposits *in situ* to be worked were reached only in the early part of 1929. On the north side the lower slopes of the hill have now been worked out and practically no ore remains below a height of about 400 feet above the plain level, but south of the main peak the ore is still unworked down to the foot of the hill.

The average iron content of the ore despatched from Gurumahisani at the present time is about 63 per cent.

The following analyses of samples taken in the course of the several examinations to which the deposits have been subjected are of interest :—

——	Iron.	Phosphorus.	Sulphur.	Silica.
	Per cent.	Per cent.	Per cent.	Per cent.
Average of eleven samples both 'solid' and 'float' ore.	61·85	0·135	0·036	4·08
Average of 20 samples of 'float' ore.	61·46	0·048	0·036	3·34
Average of ten samples of 'solid' ore.	64·33	0·075	0·021	1·64

Some of these samples were put through a complete analysis whereby were proved the absence of titanium, chromium, zinc,

nickel, cobalt (except in one case where 0·090 per cent. was found), copper, lead and barium, and the presence of arsenic in traces only (in one case up to 0·008 per cent.).

(2) Sulaipat.

The Sulaipat (or Okampad) ore deposit is situated just west of the Khorkai river, where the latter breaks through the Sulaipat-Badampahar range. Okampad is a conspicuous peak, only slightly lower than the Sulaipat peak (2,535 feet elevation) which lies one mile to the south-west of the former. Gurumahisani lies 12 miles to the north-north-east. Sulaipat ore is very rich, and is used both for open hearth and blast furnace consumption.

The average analysis of the ore for 1933-34 was as follows :—

	Per cent.
Fe	67·74
Mn	0·24
SiO_2	1·72
P	0·029

An extension of the Gurumahisani railway was completed in 1922, to Badampahar and a 24-inch gauge tram-line four miles long has been built from the Sulaipat mine to a loading siding on this extension.

The main ore-body occurs on the top of the hill, exhibiting at one point a scarp some 200 feet high and covering a superficial area of about 56,400 square feet in plan. A small outlier lies to the west of this, and these two ore-bodies were estimated by Mr. Curnow in 1915 to contain some 1,141,000 tons of ore. The 'float' at Sulaipat is very rich and was estimated at 936,000 tons, making a total of 2,077,000 tons for this deposit. The total despatches up to 31st December, 1933, amounted to 1,421,197 tons.

The removal of float ore has revealed certain bands of ore *in situ* that were not visible at the surface. These have not yet been investigated in detail, but the total amount of ore available is consequently somewhat larger than estimated in 1915.

The intimate associates of the ore are banded hæmatite quartzite, and a very fine-grained blackish quartzite superficially resembling first grade ore. The surrounding low-lying area is occupied by granite and both the rocks of the hill and the granite are cut by a network of dolerite dykes.

The last of the three major deposits occupies the Badampahar Hill (2,706 feet elevation) in the Sulaipat-Badampahar range, 8½ miles south-west from the Sulaipat ore-body. Most of the workings up to the present have been in the float ore, which is, however, not so continuous here as at Gurumahisani. The source of the 'float' is a series of small ore-bodies capping the crests of the main hill and the spurs. The absence of continuity in these deposits is probably mainly due to faulting, but there are several quite distinct types of ore at Badampahar and the relationships of the various ore-bodies are not yet worked out. The total amount of ore at Badampahar was estimated by Mr. Curnow at 8,800,000 tons in 1915, and recently further ore-bodies have been discovered.

(3) Badampahar.

A peculiar yellow ore, very light in weight and so poor in appearance that for a long time it was ignored without analysis, yielded results in certain cases as high as the following, and is now being regularly railed :—

	Per cent.
SiO_2	0·72
Al_2O_3	0·42
Fe	66·60
Mn	trace
P	0·062
S	0·15
TiO_2	*Nil*
Combined H_2O	2·40

The yellow colour is apparently due to the presence of limonite but this ore in general appears to be derived from the replacement of dolerite and the replacement is not always complete. One of the tramway cuttings has exposed an altered dolerite rock in which the percentage of iron varies from 26 to 37 per cent., and possibly it may prove to pass laterally into material sufficiently enriched to be worked as ore.

One of the deposits at Badampahar is magnetite. This is a small isolated solid ore-body and is in the neighbourhood of a peridotite dyke, with which it may be genetically connected. The bulk of the ore, however, is hæmatite of similar type to that of Gurumahisani but not so rich.

Most of the Badampahar ore is more porous than either Gurumahisani or Sulaipat and is highly regarded on that account in spite

of its lower iron content. The ore as despatched averages about 56 per cent. to 58 per cent. Fe., the average analysis for 1933-34 being as follows:—

	Per cent.
Fe	56·31
SiO_2	8·13
Al_2O_3	3·98

Iron-ores of the Kolhan, Noamundi.

Noamundi iron mine is in the Kolhan Government Estate in the Singhbhum district. The ore occurs in thick bedded deposits of hæmatite averaging well over 60 per cent. of iron. If selected material were needed there would be no difficulty in maintaining despatches averaging over 67 per cent. of iron. The ore is found on two main parallel ridges rising to a maximum height of about 1,000 feet above the railway level. It has a variable westerly dip, and is widely exposed on the dip slopes[1]. The ore at the surface is either hard and massive or laminated, but in the latter case it may be soft and shaly in appearance. It is often lateritised to considerable depths. Below 100 feet in depth it appears to be largely powdery ore ('micaceous hæmatite' or 'blue dust'), but in places it passes into powdery ore at quite shallow depths.

The mine is connected with the Bengal Nagpur Railway Company's Raj-Kharsawan-Gua extension by a broad gauge siding from Noamundi station. Despatches commenced in 1926, and the bulk of the ore despatched up to date is of the softer laminated type, averaging about 62·5 per cent. iron content, with about 4 per cent. silica and 3 per cent. alumina.

The following table summarises the tonnages despatched from all four mines during the period under review:—

Year.	Gurumahisani.	Sulaipat.	Badampahar.	Noamundi.	**Total.**
	Tons.	Tons.	Tons.	Tons.	Tons.
1929 . .	361,721	124,893	258,038	449,981	**1,194,633**
1930 . .	344,616	145,178	223,034	433,300	**1,146,128**
1931 . .	422,161	157,924	259,334	462,541	**1,301,960**
1932 . .	339,016	141,407	261,711	378,307	**1,120,441**
1933 . .	372,289	135,775	287,670	497,351	**1,293,085**

[1] For a more detailed description *see* F. G. Percival, 'The Iron Ores of Noamundi', *Trans. Min. Geol. Inst. Ind.*, Vol. XXVI, pp. 169-271, (1931).

Messrs. Bird and Company.[1]

Messrs. Bird and Company commenced exporting iron-ore from the Keonjhar State in the year 1927. The whole of the iron-ore output at present is being sold to steel works in India for use in blast furnaces. The iron-ore is quarried in the Bagia Buru ridge, north-west of Barabil village. The ridge runs parallel to the Bara Jamda-Barabil branch line of the Bengal Nagpur railway. The workings lie entirely within the Keonjhar State. The ore is hæmatite and contains 58 to 60 per cent. iron, with practically no manganese. The iron-ore being mined is partly solid-bedded ore and partly the float ore surrounding the outcrops and derived from the former.

The third grade manganese ore usually referred to by Messrs. Bird and Company as 'manganiferous iron ore', and obtained during the manganese mining and dressing operations in the same area, is also sold to steel works for blast furnace additions to give the required manganese content to the pig-iron. The ore runs between 30 and 35 per cent. manganese and about 20 per cent. iron, the latter being present in the form of limonite.

The output during the last five years has been as follows:—

Year.	Iron-ore. Tons.	Manganiferous iron-ore. Tons.
1929	187,733	8,196 (includes 38 Singhbhum)
1930	23,544	5,842 („ 184 „)
1931	111,556	20 („ 20 „)
1932	186,144	7,064 („ 19 „)
1933	195,937	10,025 (*nil*)

A very small amount of manganiferous iron-ore, as indicated above, was obtained from a number of detached plots within two or three miles of Bara Jamda station in Singhbhum.

Iron-ores of Singhbhum, Keonjhar and Bonai.

This most important iron-ore area in India, now being developed by the above-mentioned companies, is situated some 150 to 200 miles to the west of Calcutta in the province of Bihar and Orissa and contains extremely large and rich deposits of iron-ore. They occur in the Kolhan Government Estate in the Singhbhum district, and in the feudatory states of Keonjhar, Bonai, and Mayurbhanj.

[1] Information kindly furnished by Messrs. Bird and Company.

The deposits in the areas examined are remarkable for the enormous quantities of extremely rich ore they contain, and will undoubtedly prove to be amongst the largest and richest in the world.

The iron-ore usually occurs at or near the tops of hills or ranges of hills, but near Jamda in the south of the Singhbhum district and in parts of the Keonjhar State it is often found at very low levels, and in some cases actually in the plains themselves. The most important of these ranges of hills is the one that starts near Kompilai in the Bonai State, and continues to the N. N. E. to a point above three miles south-west of Gua, a distance of about thirty miles. Running more or less parallel to this range, and possibly faulted from it, are other smaller ranges which contain good iron-ore. The main range rises some 1,500 feet above the plain, and iron-ore averaging over 60 per cent. of iron occurs for practically the whole length of the thirty miles. A few small breaks occur, where the rock has not been replaced or where folding has occurred, but these are negligible compared with the total length. The rocks forming this range dip at about 70° in a direction between north-west and west.

To the east and west of these ranges, again, are more irregular patches of ore occupying the tops of hills. Large quantities of float and brecciated ore usually occur with the ore-bodies.

Mineralogy and nature of the ores.

Practically the whole of the ore is hæmatite and as far as is known no quantity of magnetite occurs in the ore-bodies. Small octahedral crystals occur in the ore occasionally; some are magnetite but they appear to be mainly martite,[1] as the rock generally has no appreciable effect on the magnetic needle. Small octahedral crystals, some of which are magnetite and some of which appear to be martite, occur also in the banded hæmatite-quartzite. The hæmatite is rather variable in character and the varieties may be grouped as follows :—

(1) Massive hæmatite.
(2) Laminated hæmatite.
(3) Micaceous hæmatite.
(4) Lateritic hæmatite.
(5) Hæmatite breccia.

[1] Registered No. L. 584, in the Geological Survey of India's collections.

The Kolhan hæmatites usually appear to contain about 64 per cent. of iron, with phosphorus ranging from 0·03 to 0·08, or in some cases to as high as 0·15 per cent. The sulphur content is usually below 0·03 per cent. Titanium in very small quantities is also said to be found occasionally in the ore. Samples from the better parts of the ore-deposits contain as much as 68 or 69 per cent. iron.

The main points of numerous analyses of these ores are the high iron content, the low percentage of sulphur and titanium, and the variability of the phosphorus content. Manganese in any quantity seems to occur only in the lateritic variety of the ore.

Distribution and quantity of ore.

The major part of the iron-ore seems to be fairly evenly divided between the Singhbhum district, the Keonjhar State and the Bonai State. The minimum quantities[1] estimated up to the present for ore averaging not less than 60 per cent. of iron are—

	Tons.
Singhbhum district	1,047,000,000
Keonjhar State	988,000,000
Bonai State	648,000,000
Mayurbhanj State	18,000,000
TOTAL	2,701,000,000

The prospecting work and mining operations carried out by the various companies indicate that the solid hæmatite often gives place to an unconsolidated micaceous powdery variety at varying depths of from 80 to 100 feet below the surface.

Geology.

The rocks of the Singhbhum iron-ore area are shown by Maclaren[2] in his account of 'The Auriferous Occurrences of Chota Nagpur, Bengal', as Dharwars. The metamorphism is, however, very much less than one expects to find in Dharwar rocks and Mr. H. C. Jones found undoubted proof near Jaganathpur, south of Chaibassa, that the Iron-ore series rests unconformably on upturned schists and quartzites of a typical Dharwar facies.

The lower beds of this younger group in South Singhbhum consist of sandstones, limestones and shales, of typical sedimentary aspect and almost unmetamorphosed, and were in the early stages of the iron-ore area survey considered to be of post-Dharwar age.[3]

[1] *Mem. Geol. Surv. Ind.*, LXIII, Pt. 2, p. 249, (1934).
[2] *Rec. Geol. Surv. Ind.*, XXXI, p. 70, (1904).
[3] *Mem. Geol. Surv. Ind.*, LIV, p. 153, (1929).

Dr. Dunn, however, has traced these almost unaltered sediments into North Singhbhum and has stated that they take on a gradually increasing metamorphic character both along the strike and across the dip, until to the north and west of Chakradharpur the rocks become typical metamorphic schists whose lithological characters are identical with those of the older metamorphics. He states that the Iron-ore series should be considered as part of the Dharwar system. The result of this work is that these rocks of South Singhbhum have been classified as 'Older Dharwars' overlain unconformably by the 'Iron-ore series' or 'Newer Dharwars'.

The 'Older Dharwar' schists and quartzites are certainly the oldest rocks recognised in the area, and after their uplift and denudation the rocks of the Iron-ore series were laid down on them unconformably. A mass of granite was then intruded into the whole, but it seems to have raised and folded the Iron-ore series rather than to have penetrated them to any large extent. This was followed by a period of basic intrusions, which took the form of dykes in the granite area, and to a less extent in the Iron-ore series. There are also large quantities of interbanded basic igneous rocks in the Iron-ore series, some of which appear to be contemporaneous with and some later than the series itself. Some ash beds have been found in the interbanded igneous rock. These intrusions of igneous material were accompanied or followed shortly after by folding and faulting of the Iron-ore series on a very extensive scale.

Intrusions of ultra-basic rocks into the Iron-ore series and possibly into the granite also occur.

The 'Older Dharwar' rocks consist mainly of quartzites with hornblende-, quartz- and mica-schists; the strike and dip are variable.

The Iron-ore series commences with a basal sandy conglomerate which passes up into a purple sandstone, ranging in thickness up to about 60 feet, and in places very coarse-grained; the conglomerate consists of angular and rounded pebbles of red jasper and white quartz cemented together by purple sandy material. The conglomerate is not always present and bands of similar conglomerate occur at different horizons in the sandstone. This conglomerate and sandstone is overlain by about 40 feet of purple and pale greyish limestone, which contains a considerable amount of fine-grained chloritic material along the bedding planes. This in its turn is overlain by a great thickness of shales, which are often very ferruginous and penetrated by thin veins of quartz. Above these shales come

banded hæmatite-quartzites comprising bands up to about an inch in thickness of hæmatite, chert and jasper in varying proportions. In places the hæmatite-quartzites are seen to pass along the strike into good ore. Above the hæmatite-quartzites is another thick group of shales, which are also often very ferruginous. Both groups of shales contain small lenticular beds of sandstone. The hæmatite occurs as a replacement product in the banded hæmatite-quartzite, and to a much less extent in the shales above and below the quartzite.

The rocks of the Iron-ore series near the granite south of Chaibassa have a general N.N.E. to S.S.W. strike and are gently folded. Towards the west the dips become greater, and the rocks have been very much folded and faulted. This faulting is well seen near Lipunga, and a strike fault apparently runs along the east side of the main iron-ore range. The rocks to the west of the fault have a very steep dip in a westerly direction. In the north part of the range the banded hæmatite-quartzites and the hæmatites have a general N.N.E.—S.S.W. strike, and dip at about 70° W.N.W.; but towards the south the strike becomes nearly N.—S. with a similar dip to the west.

Iron-ores of the Drug district, Central Provinces.

The occurrence of valuable iron-ores in the Raipur district was not appreciated before Mr. P. N. Bose briefly referred to the chief deposits.[1] The district having been explored again on behalf of Messrs. Tata Sons and Company by Mr. C. M. Weld, a large area in the Doudi-Lohara *zamindari*[2] in the western part of the district was taken up under prospecting license for detailed examination. The iron-ores, on account of their resistance to weathering agents, stand up as conspicuous hillocks in the general peneplain. The most striking of these is the ridge which includes the Dhali and Rajhara hills, extending for some 20 miles in an almost continuous zigzag line, and sometimes rising to heights of 400 feet above the general level of the flat country around. The iron-ores are associated with phyllites and are often of the usual type of banded quartz-iron-ore schists characteristic of the Dharwar system. But in places thick masses, apparently lenticular in shape, are formed of comparatively pure hæmatite, and one of these in the Rajhara hills

[1] *Rec. Geol. Surv. Ind.*, XX, p. 671, (1887).
[2] This portion of the Raipur district has been included in the new district of Drug formed in 1906.

has been subjected to very careful examination by diamond drilling. The Rajhara mass was carefully sampled across the surface at each point selected for a drill hole and the cores obtained were also analysed in lengths representing successive depths of 10 feet each from the surface, giving altogether 64 samples which were assayed for iron, phosphorus, sulphur, silica, and manganese. The average results obtained for the surface samples were as follows:—Fe, 66·35; P, 0·058; S, 0·108; SiO_2, 1·44; Mn, 0·151, per cent.; while for the cores the averages were:—Fe, 68·56; P, 0·064; S, 0·071; SiO_2, 0·71; Mn, 0·175, per cent. In this Rajhara mass the prospecting operations thus proved the existence of 7½ million tons of ore carrying about 67·5 per cent. of iron and a phosphorus content only slightly below the Bessemer limit. The quantity estimated is that which may be regarded as ore in sight, while it is almost certain that much larger quantities may be obtained by continuation of the ore-bodies beyond their proved depth. There are other large bodies of ore in this area which have not been examined in the same detail. These masses of hæmatite include small quantities of magnetite, but separate determinations of the iron in the ferric state have not been made in order to determine the relative proportions of the two minerals.

Iron-ores of the Chanda district, Central Provinces.

The Lohara hill ore-mass has been known for a long time and was described by Mr. T. W. Hughes in 1873[1], who stated that the iron-ore forms a hill three-eighths of a mile in length, 200 yards in breadth and 120 feet in height. It is reputed to contain at least 2 million tons of good quality hæmatite. Average Lohara ore is said to contain 61 to 67 per cent. iron, 1·5 to 11 per cent. silica, 0·012 per cent. sulphur, and 0·005 per cent. phosphorus.

Iron-ores of the Jubbulpore district, Central Provinces.

In addition to the results of prospecting operations conducted for the Tata Iron and Steel Company in Mayurbhanj and the Central Provinces, valuable information has been collected by Mr. E. P. Martin and Professor H. Louis in the Jubbulpore district. Prospecting operations conducted in this area showed that while iron-ore is widely distributed and the formations in which it occurs are prominent in the district, there are no rich ore-bodies of large size that could be relied on for the output necessary to maintain an important industry, and most of the ore, being in the form of soft

[1] *Rec. Geol. Surv. Ind.*, VI, Pt. 4, pp. 77—81, (1873).

micaceous hæmatite, would be physically unfit for use in a blast furnace. Generally, also, the ores in this district contain a proportion of phosphorus too high for acid Bessemer steel.

Mysore.

Iron-ores are known to occur in large quantities in the Mysore State, and have been investigated by the Mysore Geological Department. We are indebted to Dr. W. F. Smeeth for the following notes:—

The ores appear to belong to various phases of the Archæan complex and to differ considerably in their modes of origin. The hæmatite ores of the Bababudan hills are by far the most abundant and are of good quality but vary considerably in the amount of phosphorus they contain. The following classification seems to be in accordance with the numerous observations so far recorded:—

(1) Banded ferruginous quartz rock which occurs as a common integral component of the Dharwar schists. The banded ferruginous quartzites are very widely distributed and vary greatly in the respective proportions of magnetite and hæmatite present. A number of samples from the scarps of the Bababudan hills gave averages of 38 per cent. and 42 per cent. of iron, but many of the outcrops contain less. Owing to the very intimate admixture of the quartz and iron-ore grains in these rocks magnetic concentration has not proved very successful. Fine crushing is necessary but even after crushing through 60 mesh the richer concentrate (Fe, 64 per cent.) contained only 25 per cent. of the iron in the rock. With a stronger magnetic field, between 60 and 70 per cent. of the iron can be recovered in a concentrate assaying about 60 per cent. Fe. The following analyses represent averages of a large number of samples divided for convenience into three grades. The analyses are made on dried ores, the moisture being usually under 1 per cent.

———	High grade.	Medium grade.	Low grade
	Per cent.	Per cent.	Per cent.
Loss on ignition	5·23	8·87	10·61
SiO_2	1·12	1·96	3·62
Al_2O_3	2·36	3·60	9·42
TiO_2	trace	trace	0·20
Mn	0·10	0·13	trace
Fe	64·24	58·66	53·85
S	0·038	0·038	0·03
P	0·031	0·038	0·05

(2) Desilicified portions of (1) with, in some cases, addition of iron from solution or by metasomatic replacement of quartz and silicates. These form rich hæmatite and limonite ores. The banded ferruginous quartzites are usually steeply inclined, but sometimes lie nearly horizontal. This latter is the case over the eastern portion of the Bababudan hills, where these rocks form an undulating capping of from 200 to 500 feet in thickness on top of the greenstones and hornblende-schists at an elevation of about 5,000 feet. In this area the banded quartzites outcrop where there are sharp local folds or crumples, or where there has been much denudation. On the more gentle dips and undulations, solution of the silica has been active and has caused the removal of the quartz to a depth of many feet. The result is the production of a more or less banded and porous layer of hæmatite ore to a variable depth—in places 10 feet and probably deeper. A sample taken to a depth of 9 feet gave the following analysis :—

Moisture at 100° C. = 0·36 per cent.

Ore dried at 100°C.

	Per cent.		Per cent
H_2O	6·00	Fe	58·37
Fe_2O_3	82·79	P	0·057
FeO	0·54	S	0·047
MnO	0·08		
Al_2O_3	9·82		
MgO	0·26		
CaO	0·13		
SiO_2	0·77		
P_2O_5	0·13		
SO_3	0·118		
	100·38		

(3) Zones or layers of massive ore,—probably the result of the metasomatic replacement of silicates (igneous and metamorphic schists) by oxides of iron. These are either limonites or hæmatites and are sometimes associated with (1) and sometimes not. In some places they are associated with manganese-ores. Such ore-bodies have been found amongst the steeply inclined schists of the Shimoga district and also in the Chitaldroog schist belt, in both cases near or adjacent to manganese-ores. As regards quantity, there can be no doubt that a very large supply of fairly good ore can be obtained from various points on the eastern section of the Bababudan hills, but no satisfactory estimate would be possible without extensive prospecting. Of ores containing about 64 per cent. iron a few million tons could probably be obtained, but it is questionable whether it would be worth while to pick such a high grade in iron. Of ores running about 60 per cent. iron probably some 25 to 50 million tons could be obtained in several large deposits, and of lower grade ores, down to 55 per cent. iron, the quantity might safely be put at 100 millions and probably at several times this amount.

(4) Magnetite and hæmatite lenses which appear to be of magmatic origin associated with ultra-basic rocks intrusive into the Dharwar schists. They are usually highly titaniferous.

A number of long lenticular outcrops of these iron-ores have been found in the Channagiri *taluk*. The ores from a large number of outcrops have a strong family resemblance, and of the more massive varieties several hundred thousand tons are easily available. Partial analysis of a number of samples showed that the ores were all very similar, and a more complete analysis of one gave the following :—

	Per cent.
H_2O (total)	1·23
SiO_2	0·83
Fe	56·82
S	0·049
P	*nil*
MnO	0·48
Cr_2O_3	3·09
Al_2O_3	1·79
CaO	0·72
MgO	1·58
TiO_2	11·60

The large amount of titanum spoils these ores for smelting purposes. The absence of phosphorus and the presence of chromium are features of all the samples. Some ores of this series also occur in the Nuggihalli schist belt of the Channarayapatna *taluk*, where they are closely associated with chrome ores in a series of amphibolites and peridotites.

(5) Quartz-magnetite ores, which appear to be of magmatic origin and genetically related to the Charnockite series and therefore subsequent to the Dharwar schists and to the Archæan gneiss. These ores occur in the Malvalli *taluk*, north of the Cauvery river, where the charnockite masses of Kollegal penetrate the older gneiss and schists in tongues and dyke-like intrusions. They are found also in parts of the Mysore district.

Numerous gradations have been observed between the normal basic charnockite and these ores, in which we get increases in the proportion of the magnetite and quartz with diminution of the felspar and ferro-magnesian constituents, and finally a rock composed essentially of quartz and magnetite with a little accessory hypersthene, amphibole, or garnet. The rock occurs in long thin lenses or dykes in the more normal charnockites or in the older gneissic complex, and the constituent minerals are usually granular without any marked tendency to a banded arrangement.

Mysore State iron industry on modern lines.

The results of preliminary investigations carried on by the Mysore Geological Department regarding the feasibility of the manufacture of pig-iron from the iron-ore deposits of the Bababudan hills, Kadur district, and some other subsidiary deposits in the adjoining Shimoga district having been favourable, the Government

of Mysore consulted Mr. C. P. Perin, the technical expert, in 1915, to formulate for them a workable scheme for smelting the ores in charcoal furnaces. On his recommendations, the Government decided in 1918, to start the industry under the title of the 'Mysore Iron Works' at Bhadravati, 11 miles east of Shimoga. Owing to unforeseen and unavoidable delays in getting the necessary material and setting up the plant, smelting operations could not be started before 1923.

The works are located at Bhadravati, on the Birur-Shimoga branch line of the Mysore State Railway, which is about 11 miles east of the town of Shimoga, and is situated on the west bank of the river Bhadra. A new town laid out on modern principles has been built close to the works for the use of its employees. All the sections are at present under the charge of Indians, who are mostly natives of Mysore. The management is subject to the control of a board of directors and a chairman.

The raw materials are transported to the works by lines of tramways, and the Birur-Shimoga metre-gauge railway. The length of tram-lines laid out at present is 60 miles.

The main source of ore supply is the Kemmangundi ore-field, which is about $2\frac{1}{2}$ miles north-west of the Kalhatti bungalow on the top of the Bababudan hills and about 26 miles south of Bhadravati. The ore is mostly hæmatite with some limonite, and is mined in open quarries. The ore from different working spots is trollied and collected in a bin placed at the upper terminal of the ropeway whence it is fed into buckets, handed down the ropeway and dumped automatically into the open bin at the lower terminal. From here it is railed to Bhadravati. The ropeway is about 3 miles long and the vertical drop from the upper terminal at Kemmangundi to the railhead at Tanigebail is 2,000 feet. Its capacity is about 200 tons per day, and it was completed in 1924.

It was first proposed to bring the dolomite flux from a quarry at Voblapur in the Tumkur district, but the cost of transport being heavy the proposal was given up, suitable material being obtained from the subsequently opened quarry on the Shankargudda range of hills in the Shimoga district which could be supplied to the works at less cost. Limestone has, since 1929, been used as flux and is obtained from Bhandigudda (Bhadigund) near Gangur which is about $13\frac{1}{2}$ miles east of Bhadravati, and for chemical purposes from Vajra near Kondli in the Tumkur district.

The siliceous ore required for mixing with the iron-ore was, before 1929, obtained from a quarry opened up about 3 miles west of Birur, and railed to the works at Bhadravati. Since July, 1929 hæmatite-quartzite occurring in rolled boulders in the railway cutting near Tanigebail aerial ropeway terminus has been used as the siliceous ore for the blast furnace. It is not so uniform in composition as the Birur ore but costs of mining and transport are much less; its composition is as follows:—

	Per cent.
SiO_2	45 to 58
Fe	27 to 36
P	about 0·3
Al_2O_3	about 0·5

Owing to the delay experienced in completing the construction of the aerial ropeway down the slopes of the Bababudan hills and to other difficulties, the first supplies of iron-ore were got from a subsidiary deposit, which is entirely limonitic, at Chattanhalli, whence they were readily conveyed to the works by the tram and rail lines of the United Steel Co., and the Mysore Railway. Work was stopped at Chattanhalli after the completion of the ropeway.

The average analyses of ores and fluxes put into the smelting furnace are as follows:—

——	Kemmangundi iron-ore.	Limestone.	Siliceous iron-ore.
	Per cent.	Per cent.	Per cent.
Loss on ignition	7·50	40·33	0·64
SiO_2	2·00	5·17	58·85
Al_2O_3	4·00	1·00	0·75
Fe_2O_3	85·71	1·25	37·93
TiO_2	trace	*nil*	*nil*
MnO	trace	0·79	1·00
CaO	*nil*	48·67	0·50
MgO	*nil*	2·23	0·28
P_2O_5	0·14	*nil*	0·045
SO_3	0·075	*nil*	0·042

The wood required for making charcoal by distillation comes entirely from jungle trees, which cannot be made use of for any better purpose; it is being supplied from coupes which have been systematically laid out and worked in the State forests adjoining the works.

The works comprise smelting plant and the wood distillation with its by-product recovery plant. At present there is installed a single blast-furnace of the American type with complete equipment, and it has a capacity of about 80 tons of pig-iron per day. The distillation plant comprises a set of ovens for burning wood in closed chambers and converting it into charcoal, and a system of pipes and apparatus designed for the recovery of the by-products—wood-alcohol, acetate of lime and wood-tar. After five years of construction, production work was commenced in the month of January, 1923. The daily output of pig-iron has gradually risen from 40 to 60 tons per day to the maximum capacity of 75 tons per day.

The annual output of the ores and fluxes in tons for the calendar years 1929-1933 are :-

Year.	Kemmangundi iron-ore.	Gangur manganese-ore.	Gangur limestone (Flux).	Vajra limestone (Chemical purposes).	Tanigebail siliceous iron-ore.
1929 . .	42,940	..	..	1,968	1,734[1]
1930 . .	28,013	326	781	910	3,486
1931 . .	15,782	547	881	1,069	2,735
1932 . .	2,078	334	..	..	2,316
1933 . .	32,122	270	2,198	551	2,919

The output of pig-iron during the five years has been :—

	Tons.
1929	21,452
1930	20,668
1931	15,577
1932	14,683
1933	14,805

[1] Up to July, 1929, 1,254 tons of siliceous ore were obtained from Birur.

The results of analyses of this pig-iron show :—

Si	0·2 to 3·5	per cent.
Mn	0·2 to 2·5	"
C (total)	3·5 to 4·8	"
P	0·06 to 0·15	"
Cr	0·02 to 0·03	"
S	0·02	"
Fe	92 to 94	"

A portion of the pig-iron is used for casting and in the pipe foundry and the rest is sold as pig-iron.

The present daily output of the by-products is :—

Lime acetate	1·5 tons.
Alcohol	150 gallons.
Tar	1 ton.

Kankar from Dronachallam, Kurnool district, was being used primarily for the manufacture of acetate, but now lime-kankar is being obtained from several places in the State.

The output of by-products for the years 1929-1933 has been :—

——	1929	1930	1931	1932	1933
Acetate (in tons) . .	1,793	1,698	817	240	461
Alcohol (in gallons) . .	130,474	183,637	84,583	32,570	49,510
Tar (in tons) . . .	636	1,464	996	261	392

The sales of these products have been chiefly outside the State. Labour is imported mostly from the Mysore, Tumkur, Kolar and Chitaldrug districts of the State, but a small percentage is also imported from Malabar and Salem. About 200 coolies are employed in the iron mines; they are provided with suitable huts for living purposes.

Goa and Ratnagiri.

The iron-ore of the Goa and Ratnagiri areas is of Dharwar age and crops out in the midst of laterite[1]. As seen at the outcrop, it is a hard ore composed either of limonite or of hæmatite containing minute crystals of magnetite. At Bicholim, 22 miles from the port of Marmagao in Goa, the principal ore band has been traced for a distance of 7 kilometres and is said to vary in width from 30 to 100 metres. Prospecting work carried out by the 'Compagnie des Mines de Fer de Goa' in the Portuguese territory of Goa, and by Messrs. Jambon and Company

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XLIII, p. 18, (1913).

in the adjoining British district of Ratnagiri indicated that this hard ore is probably the surface, hydrated form of friable schistose micaceous hæmatite, which is found unaltered at a relatively small distance, approximately 50 feet, below the surface. On account, however, of the extent of the outcrops, the hard superficial ore is probably available in large quantities, and, as analyses indicate it to be of high grade, with a very low percentage of silica, and phosphorus below the Bessemer limit, it seems probable that Goa possesses valuable iron-ore reserves. Some of the deposits are only 4 miles from navigable water and it is therefore not impossible that iron-ore may be mined at some time for export.

Hyderabad.

Production of iron-ore in small quantities is reported from the following localities: Asafabad, Khammammett and Karimnagar.

The native smelting industry.

The indigenous methods of smelting iron in various districts in India have been frequently described, and no new features in the methods have recently been noticed. The industry still persists in a few districts of Bengal and Bihar and Orissa; in the Kumaon hills; in Mysore; in the districts of Malabar, Salem, and Trichinopoly of Madras; in Hyderabad; and in several states in Central India and Rajputana. The industry persists to a greater extent in the Central Provinces than elsewhere. Returns are now being made from five districts and from the Table it seems that the indigenous industry is gradually dying out as during the last quinquennium an average of 210 furnaces were reported annually. At one locality, Ghogra, in the Jubbulpore district, manganiferous iron-ore is smelted with the production of a steely iron known as *kheri*[1].

TABLE 51.—*Number of iron-smelting furnaces at work in the Central Provinces during the period 1929 to 1933.*

—	1929	1930	1931	1932	1933
Bilaspur	95	53	53	59	52
Drug	11	..	..	4	5
Mandla	53	57	49	51	54
Raipur	12	13	3	3	2
Saugor	3	1	1	1	1
Total	174	124	106	118	114

[1] *Mem. Geol. Surv. Ind.*, XXXVII, p. 595, (1909).

The native smelting industry in Garhwal.

Iron-ore occurs at numerous places along the outer Himalaya, the rocks being similar lithologically to some of the Dharwars of Peninsular India. Owing to the abundance of timber and, until recently, to the absence of railway transport by which cheap foreign iron and steel are distributed, the *lohar*, or *agaria*, as the native smelter is sometimes called, flourished to a later date than in the more accessible parts of the Peninsula, and the industry of iron-smelting still persists in a languishing condition. The necessity of curtailing the indiscriminate cutting of forests, the readiness with which a large variety of foreign implements can be obtained in the bazars, and the higher wages obtainable on account of the general progress of the country have all combined to encourage the *lohar* to leave his ancestral calling for other industries, although a few workers still occupy their leisure during slack seasons in smelting, and the native-made product is preferred to foreign iron when it can be obtained readily.

Kashmir.

Iron[1] was once worked at several places in Jammu and Kashmir State, and the suspension bridge at Ramban over the Chenab river was built of iron smelted from the ores of the Riasi *tehsil* of Jammu, during the reign of the late Maharajah Ranbir Singh. A bed of hæmatite, 15 feet thick, and containing 60 per cent. of iron, has been located by the Mineral Survey of the State at Khandli in Rajouri, forming lenticular masses in the Nummulitic series.

Protection.

Owing to a world-wide slump in the iron and steel trade, the industry was not prosperous in the early part of the last quinquennium and its conditions were investigated by the Indian Tariff Board and a measure of protection introduced for steel in 1924. The Steel Industry (Protection) Act was passed in 1924, and granted, up to the 31st March, 1927, to companies employing Indians, bounties upon rails and fishplates wholly manufactured in British India from material wholly or mainly produced from Indian iron-ore and complying with specifications approved by the Railway Board, and upon iron or steel railway wagons a substantial portion of the component parts of which had been

Act No. XIV of 1924.

[1] 'Mineral Resources of Jammu and Kashmir State', p. 12, (1931).

manufactured in British India. These bounties were increased in 1925, and protective duties were suggested.

This Act was repealed by Act No. III of 1927, and consequently the payment of bounties ceased on the 31st March, 1927, but the industry is protected to a certain extent by varying tariffs on different classes of imported steel. This protection was given for seven years commencing from 1st April, 1927, and the Bill provided for a statutory inquiry in the fiscal year 1933-34, to ascertain what amount of protection might still be necessary.

As a result of this inquiry Act No. XXXI of 1934 has provided for an increase of tariffs by about half over the 1927 rates, or about Rs. 10 per ton *ad valorem* in most cases, or Rs. 40 per ton more or less in the case of articles not of British manufacture.

Imports.

Except for the pig-iron and steel produced at Kulti (Barakar), Jamshedpur and Burnpur, the greater part of the iron and steel used in India is imported. The steel furnaces in the Government ordnance factories consume 80 tons of indigenous pig-iron and 590 tons of imported pig-iron annually. To the former figure, however, should be added 3,200 tons of high class scrap supplied by steel makers in India, which is produced entirely from indigenous pig. With the exception of about 435 tons of special pig-iron, all pig-iron used by the East Indian Railway works at Jamalpur until the steel foundry closed down in March, 1931 was of Indian origin. The iron produced by primitive Indian methods probably amounts to less than 1,000 tons a year. The requirements of the country in iron and steel are indicated by the import returns summarised in Table 5[illegible]. From this it will be seen that the total value of the unfinished and finished iron and steel products imported into India has remained fairly constant during the quinquennium, but the average value has decreased from 49,35,32,283 rupees in the last quinquennium to 29,66,24,073 rupees in the period under review.

Production of pig-iron.

The total production of pig-iron in India amounted to 1,391,551 tons in 1929, 1,175,292 tons in 1930, 1,058,336 tons in 1931, 913,314 tons in 1932 and 1,057,837 tons in 1933. The average production during the quinquennium amounted to 1,119,266 tons.

Exports of pig-iron fell from 548,881 tons valued at Rs. 2,50,86,155 in 1929 to 248,396 tons valued at Rs. 86,65,502 in 1932. A slight

TABLE 52.—*Imports into India of Iron and Steel materials during the years 1929 to 1933.*

—		1929	1930	1931	1932	1933	*Average.*
Cutlery and hardware (*a*) .	Rs	5,69,79,480	4,47,11,481	3,37,36,689	3,06,41,675	3,19,63,976	*3,96,06,660*
Machinery and millwork (*a*)	,,	21,58,23,118	18,86,88,956	13,42,30,983	11,02,75,964	12,87,40,082	*15,55,51,821*
Iron bars, pig-iron, etc. .	,,	15,06,400	12,99,908	5,95,229	6,54,627	7,94,299	*9,70,093*
	Tons	11,027	8,646	4,680	4,721	6,418	*7,098*
Iron and steel beams, sheets, pillars, rivets, etc.	Rs.	16,12,32,372	11.31,85,835	6,25,97,840	4,65,90,979	4,52,56,932	*8,57,72,791*
	Tons	824,529	567,795	328,290	329,000	238,559	*457,635*
Steel bars, angles and channels, ingots, blooms, billets, etc.	Rs.	3,16,17,559	1,56,93,801	1,05,08,531	81,19,873	76,73,776	*1,47,22,708*
	Tons	270,839	136,014	109,803	91,330	73,573	*136,312*
Total value .	Rs.	46,71,58,929	36,35,79,981	24,16,69,272	19,62,83,118	21,44,29,065	*29,66.24,073*

(*a*) Figures for quantities are not available. Railway plant and rolling-stock to the value of Rs. 1,14,34,048 were imported during the three months January-March 1928, but statistics are no longer available.

TABLE 53.—*Exports of Pig-iron from India during the years 1929 to 1933.*

—	1929	1930	1931	1932	1933	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
To—						
United Kingdom.	43,905	116,762	51,600	85,332	82,823	*76,084*
Germany .	13,243	10,307	14,332	8,543	5,518	*10,388*
China . .	12,226	18,329	16,307	10,566	18,066	*15,099*
Japan . .	385,158	201,907	157,116	101,983	179,506	*205,152*
United States of America.	68,017	108,924	60,121	26,978	71,951	*67,198*
Other countries	26,332	46,310	19,518	14,994	14,156	*24,262*
TOTAL .	**548,881**	**502,629**	**318,994**	**248,396**	**372,015**	*398,183*
Total value in Rs.	2,50,86,155	2,06,99,058	1,12,03,467	86,65,502	91,07,292	*1,49,52,295*
Total value in Sterling.	*£1,872,101* (£1 = Rs. 13 4)	*£1,533,263* (£1 = Rs. 13·5)	*£829,886* (£1 = Rs. 13·5)	*£651,542* (£1 = Rs. 13·3)	*£684,759* (£1 = Rs. 13·3)	*£1,114,310*

Exports. increase in exports to 372,015 tons valued at Rs. 91,07,292 was experienced during the last year of the quinquennium. The annual average for the quinquennium was 398,183 tons valued at Rs. 1,49,52,295 as compared with 360,119 tons valued at Rs. 1,79,28,695 for the period 1924-1928. In the quinquennium under review, the United Kingdom and Japan were the principal consumers of Indian pig-iron, although the American consumption in 1929 and 1931 exceeded that of the United Kingdom.

Jadeite.

[L. L. FERMOR.]

Jade is a name popularly applied to certain semi-precious stones usually of a green colour, which belong to at least two distinct mineral species, nephrite and jadeite. On account of their toughness, colour and supposed magical properties they have been treasured by mankind from the earliest times. Celts and carved ornaments of jade and jadeite have been found in many prehistoric sites both in

Europe, Asia and North America. These ancient beliefs have descended through the centuries to the modern Chinese who prize and revere the stone, which they believe confers on the wearer immunity from accident and ill fortune and is the symbol of purity in private and official life. At the same time an admiration for the remarkable beauty of Burmese jadeite has gradually grown up in western lands where it has become a favourite article of feminine adornment.

Exports and prices.

The winning of the mineral forms an important industry in the Myitkyina district of Upper Burma. A certain quantity of the stone passes by the overland route to Têng-yüeh in Yunnan, where it is marketed, cut, polished and distributed to the western provinces of China, but most of it finds its way down to Rangoon, through Mogaung and Mandalay, whence it is exported to the Straits Settlements and various Chinese destinations.

The official returns of jadeite production are anomalous and little reliance can be placed upon them. The export figures which have been used as a fairly reliable indication of the state of the industry in the past are now vitiated, as the trans-frontier trade returns are no longer collected. Such figures as exist, however, are given below :—

TABLE 54.—*Production of Jadeite during the years 1929 to 1933.*

YEAR.	Quantity.	*Value.*	Value per cwt.
	Cwts.	*Rs.*	Rs.
1929	3,450·9	*2,77,356*	80·4
1930	1,499·0	*3,66,487*	244·5
1931	2,765·0	*7,72,860*	279·5
1932	3,025·8	*3,26,373*	107·8
1933	1,170·8	*1,29,444*	110·6
Average .	*2,382·3*	*3,74,504*	*164·6*

TABLE 55.—*Exports (a) of Jadestone from Burma during the years 1929-30 to 1933-34.*

YEAR.	Quantity.	*Value.*	Value per cwt.
	Cwts.	*Rs.*	Rs.
1929-30	2,137	*4,86,156*	227·5
1930-31	1,475	*2,18,522*	148·2
1931-32 (*b*)	2,500	*3,52,264*	140·9
1932-33 (*c*)	2,654	*3,77,178*	142·1
1933-34 (*d*)	1,799	*1,79,723*	99·9
Average .	*2,113*	*3,22,769*	*152·8*

(*a*) Shipments from Burma.
(*b*) Exports from Burma by land amounted to 51 cwts.
(*c*) ,, ,, ,, ,, ,, 110 ,,
(*d*) ,, ,, ,, ,, ,, one cwt.

These figures may be compared with those for the previous quinquennium when the annual production averaged 2,120·6 cwts. valued at Rs. 177·4 per cwt. and the exports, 2,107 cwts., valued at Rs. 211·2 per cwt. In any one year the figures of production and exports cannot be expected to tally, but if the figures for five years be considered it is seen that the figures of production and exports are commensurate with one another, the production exceeding exports by the small figure of 269 tons annually, a figure that must be in excess of the truth, as the export figures do not include the overland exports for the first two years. As it is also certain that the quantities of the stone used in the manufacture of jewellery in the cutting centres of Mandalay and Mogaung, are either absorbed in Burma or exported without appearing in the returns, it seems probable that the figures of production are understatements. Another important factor with the same effect is the amount of mineral lost in cutting the stone before export.

There has unquestionably been a marked decline in exports and the average figure of 2,113 cwts. in this quinquennium and 2,107 cwts. in the previous quinquennium compare very unfavourably with 4,628 cwts., the average not only for the quinquennium

1919-1923, but approximately that of the three similar earlier periods. In the trade the decline is said to be due to troubled political conditions in China. The average value of the exported stone has also declined remarkably from Rs. 318·8 in 1919-1923 to Rs. 211·2 per cwt. in 1924-1929 and again to Rs. 152·8 per cwt. in 1929-1934, though it is doubtful whether these figures possess any real significance.

Value of Jade.

To the Chinese the different varieties of both nephrite and jadeite, and possibly other minerals of similar appearance, are known as *Yu* or *Yu-chi*. They are emblems of virtue and stand high in the ranks of their precious stones. Bowenite, a jade-like variety of serpentine, passes on the north-west frontier under the name of *sang-i-yeshm* and is frequently met with in eastern bazaars carved into drinking cups, trinkets and beads. Chinese dealers in Burma classify jadeite into many different kinds, the values of which fluctuate within very wide limits. This is not surprising in a mineral which may possess any colour from pure white, through all the shades of green to amethystine, mauve, violet and light blue, yellow and orange, to various tints of brown, red and black. One broad distinction is made between *aye* and *athakyauk* (*kyauk* is Burmese for stone), and to the former belong all the beautiful green varieties of varying degrees of colour, translucency and texture. The mineral has no fixed market value and the prices which it brings depend on the taste of the buyer and the state of his pocket. The most precious of all the classes in the *ayekyauk* section is known as *myaye*; it is a uniform translucent green which is best compared with the emerald or, in Chinese phraseology, with the green in a peacock's tail. It is worth anything from Rs. 500 to Rs. 10,000 per *viss* (1 *viss*=3·6 lbs.). *Shweluye* has a lighter tint of green with brighter spots and streaks. It is said to be worth from Rs. 100 to Rs. 5,000 per *viss* and like the former is used in the manufacture of expensive jewellery. Other varieties of the same section include *peye*, a pea green stone of much the same value as *shweluye*, and *latye*, a translucent sage green variety valued at Rs. 500 to Rs. 1,000 per *viss*. For fancy cut pieces of perfect specimens of some of these varieties values are officially stated to range between Rs. 20 and Rs. 1,500 per *tola*, (1 *tola*=180 grains).

Turning now to the other section, or *athakyauk*—*atha* in Burmese means flesh, but it here includes all the brilliant white varieties of

the mineral of all degrees of translucency and limpidity—the ordinary cheaper varieties include *athayo*, *hnawswe* and *athapukyi*, which vary in value from a few annas to as many rupees per *viss*. They are used in the manufacture of cheap jewellery, pipe stems, plates, cups and saucers, etc. *Pantha*, which possesses a certain amount of opacity, is used for decorative inlaid work.

It is unnecessary to burden this list any further with vernacular terms and it only remains to state that of the unusual colours the shades of mauve, violet, blue and amethystine are the more valuable ranging from a few rupees up to Rs. 500 per *viss*, orange and brick red tints attain a maximum of Rs. 300 per *viss*, yellow comes next at Rs. 200, followed by rust red, which, like the others, starts at about Rs. 20 for the poorer kinds but only reaches Rs. 100 per *viss*, while black jadeite can be purchased for Rs. 10 to Rs. 80 per *viss*. In the compilation of this section[1] much assistance has been derived from lists courteously furnished by Mr. C. W. Chater, the well-known authority on jade, and by the Deputy Commissioner of Myitkyina.

The figures quoted certainly prove that the values of the mineral given per cwt., in the export returns, are fallacious.

Composition.

Two distinct minerals are included in the term *jadestone* or *jade*, nephrite, which is a variety of tremolite or actinolite, a silicate of calcium and magnesium, $CaO.3MgO.4SiO_2$, and a member of the amphibole group; and jadeite, a compact alkali pyroxene, $Na_2O.Al_2O_3.4SiO_2$, a silicate of sodium and aluminium. The white and greenish varieties of the stones are often confused and they are both equally valued by the Chinese. Though tough and splintery like nephrite, jadeite is slightly harder, considerably heavier and more easily fusible than the other.

No nephrite of the kind that would be regarded as a marketable stone is known in India; but a mineral, having the essential composition, and approaching coarse jade in physical characters, is known in South Mirzapur[2]. Nephrite jade, however, has been worked in the Karakash valley in south Turkestan for many centuries[3].

[1] Written originally by Dr. J. Coggin Brown.
[2] F. R. Mallet, *Rec. Geol. Surv. Ind.*, V, p. 22, (1872).
[3] *Cf.* papers quoted by Mallet in Manual, Geology of India, Part IV, p. 85, (1887).

The only jadestone of commercial importance within the Indian Empire is the jadeite that occurs in the valley of the Uru river, a tributary of the Chindwin, in the Mogaung sub-division of the Myitkyina district, Upper Burma. The most interesting of a number of occurrences in this region is at Tawmaw (25° 41′; 96° 15′) where alluvial jadeite has probably been known to occur for a very long time but where the mineral was first discovered *in situ* about 50 years ago. Accounts of the occurrences have been published by Dr. F. Noetling[1] in 1893, and by Dr. A. W. G. Bleeck in 1908[2]. A systematic geological survey of the region has lately been undertaken by Dr. H. L. Chhibber of the Geological Survey of India and the short summary given below is based on the results of his work.

Mode of occurrence.

The Tawmaw dyke, which is under active exploitation, and the three others of Meinmaw, Pangmaw and Namshamaw, all of which bear deserted outcrop workings, consist of albite-jadeite rock intruded into the northern end of a great elongated mass of partially serpentinised peridotites, which has been traced for a distance of over twenty miles in an approximately N.E.—S.W. direction. Its southerly limits are still unknown.

The ultrabasic rocks are themselves intrusive into a series of crystalline schists, which appear to encircle them. They consist of graphite-, glaucophane-, vesuvianite-, hornblende-, chlorite-, kyanite- and quartz-schists, together with igneous rocks ranging from diorites and gabbros to pyroxenites and perknites; epidiorite derived from gabbro is the commonest type. The more important varieties of the ultrabasic intrusives are altered dunites, mica-, hornblende- and diallage-peridotites, pyroxenites and amphibolites. Brecciation and serpentinisation are widespread and various varieties of serpentine such as antigorite, marmolite and the massive dark green mineral occur.

On the Tawmaw dyke are situated the two mines of Dwingyi and Kadondwin, which really consist of a series of shafts from which a number of drives have been made along the dyke itself. As exposed in the Kadondwin, the jadeite occurs in the form of large lenses from 5 to 7 feet thick in the albite of the footwall side. A thin layer of amphibolite often separates the two minerals, while the enclosing rocks consist of chloritic schist and brecciated

[1] *Rec. Geol. Surv. Ind.*, XXVI, pp. 26-31, (1893).
[2] *Op. cit.*, XXXVI, pp. 254-295, (1908).

serpentine. The existing working face is about 21 feet across and on the hanging wall side is filled in with a breccia composed of amphibolite, albite and jadeite in a calcareous matrix.

Dr. Bleeck believed that the jadeite was formed as a result of the metamorphism of an albite-nepheline rock, but according to Dr. Chhibber the mineral is an original magmatic segregation product.

The mines are only worked for three months during the year and are flooded every rainy season; methods are crude in the extreme, though the use of compressed-air drills and steam-driven hoists has been introduced lately.

In addition to these underground workings, large quantities of jadeite are won in the form of alluvial boulders from certain Tertiary deposits and from the Uru boulder conglomerate, both of which fringe the great serpentine mass, with its jadeite-albite dykes, on the east. The Tertiary rocks consist of sandstones, shales and conglomerates, and in the latter, boulders of serpentine and jadeite are of frequent occurrence. Most of the workings, tunnels, quarries and pits are grouped around Kansi (25° 47′; 96° 23′), Lonkin (25° 39′; 96° 22′) and Hwehka (25° 29′; 96° 17′).

The Uru boulder conglomerate, which is often hundreds of feet thick and is believed to be of sub-Recent age, contains water-worn boulders of most of the metamorphic and igneous rocks of the district, together with serpentine and jadeite. Active workings in it are mostly clustered around Hpakan (25° 37′; 96° 19′) and Mamon (25° 35′; 96° 16′). Jadeite boulders are also obtained by diving into the pools of the Uru river, which they have reached by the ordinary processes of recent denudation.

History of the jadeite trade.

The following notes on the history of the jadeite industry are taken from Mr. W. A. Hertz's Myitkyina District Gazetteer (1912), where the interested reader will find a full account of the complicated administrative systems which have grown up around the industry as a heritage from the past. In the following paragraphs the term *jade* is used in its generic sense, referring in the case of Burma to jadeite.

According to Mr. Warry of the Chinese Consular Service, the discovery that green jade (jadeite) of fine quality occurs in Northern Burma was made accidentally by a small Yunnanese trader in the thirteenth century, who, to balance the load on his mule, picked up

a piece of stone, which was later found to be jade of great value. For some centuries small pieces of stone found their way across the frontier, but it was not until 1784, after protracted hostilities between Burma and China, that a regular trade was opened between the two countries and then the Chinese soon discovered the position of the jade-producing district. At the beginning of the nineteenth century the Burmese kings seem to have become aware of the importance of the jade trade and the revenue it might yield, and in 1806, a Burmese collectorate was established at the site of what is now the town of Mogaung, which became the headquarters of the jade trade in Burma. The Kachins, in whose country the jade deposits are situated, and who were regarded as the absolute owners of all the jade produced, brought the mineral to Mogaung, where it was sold to the Chinese. When it was ready to leave Mogaung an *ad valorem* duty of $33\frac{1}{3}$ per cent. was levied and a permit issued. Payments were made in bar silver—at first fairly pure, but later on debased with lead (rupees did not come into general use until 1874).

The period of greatest prosperity of the jade trade was between 1831-40, during which time at least 800 Chinese and 600 Shans were annually engaged in business and labour at the mines. All the stone went by one of the several routes to Yunnan Fu, then the great emporium of the jade trade, where Cantonese merchants bought the rough stone and carried it to Canton to be cut and polished. In 1841, war broke out between Great Britain and China and the hostilities at Canton soon affected the jade trade, so that the Cantonese merchants ceased to go to Yunnan Fu to buy stone. Stocks accumulated and Yunnanese traders ceased visiting the mines. The trade passed through various vicissitudes, but it was not until 1861 that it really improved again. From that date, when the first Cantonese merchant arrived in Mandalay and made a fortune by buying up all the old stocks of jade, till now, the bulk of the stone has been carried by sea to Canton. During the ensuing years, the jade dues were sometimes collected in the orthodox way—by the Collector at Mogaung—whilst in other years the tax was farmed out; but the King of Burma, dissatisfied with the revenue thus obtained from jade, tried in some years to purchase all the material himself direct from the Kachins at the mines. In such years the Kachins, preferring the former revenue methods, curtailed the output and produced pieces of inferior quality only.

The revenue accruing to the King from the jade dues varied from Rs. 10,000 per annum to Rs. 50,000, being least when the King tried to purchase the jade himself. With the British occupation of Upper Burma the tax was farmed out to Lo En Pin, who made himself so unpopular by his methods of collecting the tax that he was murdered at Mogaung. The first British visit to the mines was made in 1888, by Major Adamson with a column of British troops. The tax of 33⅓ per cent. on output is still farmed out by Government.

Before the mineral leaves the mines certain payments have to be made to the local Kachin chiefs (the Kansi or Hwehkha *duwas*), which are stated to be a ten per cent. *ad valorem* tax known as *manhumanta* and a toll of Rs. 2-8 on every mule load, or Re. 1 on every coolie load of jadeite removed. The stone is then taken to Mogaung, where the *ad valorem* royalty of 33⅓ per cent. is assessed by a valuation committee of merchants, and has to be paid before the stone is permitted any further afield. The right to collect this royalty and another one of 5 per cent. on the amber from the Hukong valley is still farmed out by Government. During the period under review the amounts realised on this account, year by year, were :—

Year.	Rs.
1929-30	1,64,500
1930-31	1,92,000
1931-32	1,92,000
1932-33	88,875
1933-34	54,875

The years given above are the agricultural years ending the 30th June. It will be seen from these figures that there has been a great fall in the amount realised during the last two years of the quinquennium. In the previous quinquennium the amount realised was Rs. 95,600 per annum, which was Rs. 34,400 per annum less than in the previous period of five years. Although there has been a slump in the jadeite trade during the past five years, the amounts realised from the sale of the right to collect these royalties do not correspond with the state of the jadeite market. The system of farming out the right to collect these royalties is therefore unsatisfactory.

Jadeite has been found in the Kachin Hills near Mawhan in the Mogaung Township of the Myitkyina district (formerly in the

Katha district), Mawlu township of the Katha district, Upper Burma, and is also reported from Tibet. Jade (nephrite) is stated to occur in the corundum quarries of Pipra, Rewah State.

Lead.

[E. L. G. CLEGG.]

Northern Shan States: production and ore reserves.

The history of the lead industry in India continues to be, for all practical purposes, the record of the exploitation of the great ore deposit at Bawdwin in the Northern Shan States of Burma and the development of the metallurgical and milling processes there. The current records of this enterprise open during the quinquennial period 1909-1913 with the production of 46,000 tons of lead; during the next period. 1914-1918, in spite of the difficulties caused by the war, 73,817 tons of lead were extracted; in the next period, 1919-1923 the production had increased to 161,902 tons; in the next, 1924-1928, despite a small set back in 1925 owing to mine fires, an increase was again recorded, 297,715 tons of lead being produced. During the period under review, although a total increase of production to 377,995 tons (includes 6,532 tons of antimonial lead) was registered, the revenue derived from this shows a depressing decrease to Rs. 7,89,51,001 compared with the Rs. 11,24,41,670 derived from the production of the last quinquennial period. This fall in revenue reflects the crisis through which lead mining has passed during the period and is reflected in the annual output of lead shown in Table 56. To explain this steady fall from a record output of 79,033 tons in 1929 to 70,560 tons in 1932 and 1933, one must look to the state of the lead industry in general.

From 1921 when the world's production of lead was about 880,000 tons and the price £22-15 per ton, there was a steady rise in both production and price to 1925, when 1,549,000 tons were produced at an average of £36-8 per ton. The high prices prevailing stimulated the search for new mines and efforts to augment the production from existing properties, and production continued to increase to 1927 when the world's output totalled 1,634,200 tons. The price, however, failed to remain at the high level obtaining in 1925, and dropped to £31-2-3 in 1926 and £24-8-1 in 1927. This fall in price was responsible for a slight fall in output in 1928, to 1,622,775

TABLE 56.—*Production of Lead from Bawdwin during 1929-1933.*

—	Total ore mined.	Lead extracted.	*Value in Rupees.*	*Value in Sterling.*
	Tons.	Tons.	*Rs.*	£
Average 1924-28	*372,798*	*58,523* *(a) 1,020*	*2,22,16,203* *2,72,131*	*1,668,094*
1929 . . .	463,972	79,033 (a) 1,200	*2,46,63,512* *3,37,101*	*(b) 1,865,717*
1930 . . .	529,814	78,030 (a) 1,700	*1,81,49,622* *3,54,994*	*(c) 1,370,712*
1931 . . .	397,679	73,280 (a) 1,505	*1,26,88,725* *1,99,545*	*(c) 954,687*
1932 . .	372,586	70,560 (a) 642	*1,09,07,447* *88,140*	*(d) 826,736*
1933 . . .	454,791	70,560 (a) 1,485	*1,13,22,552* *2,39,363*	*(d) 869,317*
TOTAL .	2,218,842	371,463 (a) 6,532	*7,77,31,858* *12,19,143*	*5,887,169*
Average 1929-33 .	*443,768*	*74,293* *(a) 1,306*	*1,55,46,372* *2,43,828*	*1,177,434*

(*a*) Antimonial lead. (*b*) £1 = Rs. 13·4. (*c*) £1 = Rs. 13·5. (*d*) £1 = Rs. 13·3.

tons, a few properties shutting down on finding themselves unable to operate at a profit. The average price for the year was £21-3-3, but in 1929 better prices prevailed over the greater part of the year and so stimulated output that a record world's production of 1,724,338 tons of lead was attained. All however was not well. Since 1927 there had been an increasing disparity between consumption and production. In 1928 this disparity had caused a certain amount of apprehension among lead producers, but after meeting and reviewing the situation they had considered it unnecessary to restrict output for the time being. In 1929 the seriousness of the situation was fully realised and led to the formation in October of a lead producers' association to try and balance production with consumption.

This association functioned throughout 1930 and succeeded in restricting output to a slight extent to 1,625,000 tons but not sufficiently to arrest the downward price of the metal, which averaged £18-1-5. In 1931 acute depression in the lead-consuming industries still persisting, a restriction of 15 per cent. output was made by the producers' association for six months from May 1st and further increased to 20 per cent. from July 1st. This reduced the output to 1,401,000 tons, but proved insufficient to balance supply and demand, and at the end of the year there was again an estimated increase of world's stocks of the metal. The yearly average price of the metal had fallen to £13-0-4, despite the fillip it had received owing to England's abandonment of the gold standard in September and the consequent rise of sterling prices, which, incidentally, considerably improved the position of Empire producers. In the beginning of March, 1932, the International Association of Lead Producers was dissolved and it was left to natural economic laws to adjust the position. The world's output declined to 1,138,000 tons and the average price showed a further decline to £11-18 per ton. In 1933 the slow recovery in world trade was responsible for the balancing of the world's supply and demand, but not sufficient to remove the huge accumulation of lead stocks which still remained to depress the market. The world's output increased to 1,164,000 tons whilst the average price of the metal for the year declined slightly to £11-16 per ton.

In 1930, the Burma Corporation abandoned their intention of increasing their lead output by milling a somewhat lower grade of ore and their output at 78,030 tons was 1,003 tons less than their record production of 1929. In 1931, in conformity with the lead producers' association, they further restricted their output to 73,280 tons, meanwhile considerably reducing their production costs and attaining a higher degree of metallurgical efficiency. Further voluntary reduction of output to 70,560 tons was made during 1932 and 1933 in pursuance of the company's policy of 'restriction until the position of supply and demand showed that additional metal would not affect the price level.'

In 1919, the Burma Mines, Limited, which up to that time had been a London concern, was reorganized with its headquarters in Rangoon as the Burma Corporation, Limited. This corporation now possesses a total authorized capital of 20,000,000 shares of Rs. 10 each, of which 13,541,689 shares have been issued. A first

mortgage 8 per cent. convertible debenture issue of £1,000,000 was redeemed during the 1924-1928 quinquennial period. The magnitude of the finances involved and a study of the ore reserves given below will convey some impression of the size of this industry that has been developed in the heart of the Shan jungles, 600 miles inland from Rangoon and only 40 miles from the Chinese frontier.

TABLE 57.—*Ore Reserves as on July 1st, 1933.*

	Tons.	Ag. ozs. (per ton).	Pb. per cent.	Zn. per cent.	Cu. per cent.
Total Chinaman lode (proved and probable).	6,038,245	22·2	26·2	16 6	0·5
Total Shan, Burman and Kachin lodes (proved and probable).	1,995,762	18·9	22·6	10·7	2·33
Meingtha lode (proved and probable).	964,499	15·3	19·5	12·1	1·05
Total (proved and probable) .	8,998,506	20·8	24·7	14·8	0·94
Extracted	4,867,758	21·7	24·0	14·1	1·16
Reserve in mine . . .	4,130,748	19·6	25·5	15·5	0·68
Ore stocks	3,044	19·0	22·8	13·3	0·79
Total ore reserve .	4,133,792	19·6	25·5	15·5	0·68

Included in this reserve are 126,754 tons of copper ore assaying:—

Ag. ozs. (per ton).	Pb. per cent.	Zn. per cent.	Cu. per cent.
18·2	14·5	6·9	6·9

The total reserve at the end of the previous period as on 1st July, 1928, was as follows :—

Tons.	Ag. ozs. (per ton.)	Pb. per cent.	Zn. per cent.	Cu. per cent.
4,099,684	21·5	25·9	16·0	1·16

showing an increase of 34,108 tons for the period under review.

The following ore was extracted from the mine during the period :—

	Tons.
Lead zinc ore	1,754,430
Copper ore	460,867
TOTAL .	2,215,297

This total, with the increase of 34,108 tons in the reserve, represents the amount of ore developed during the period.

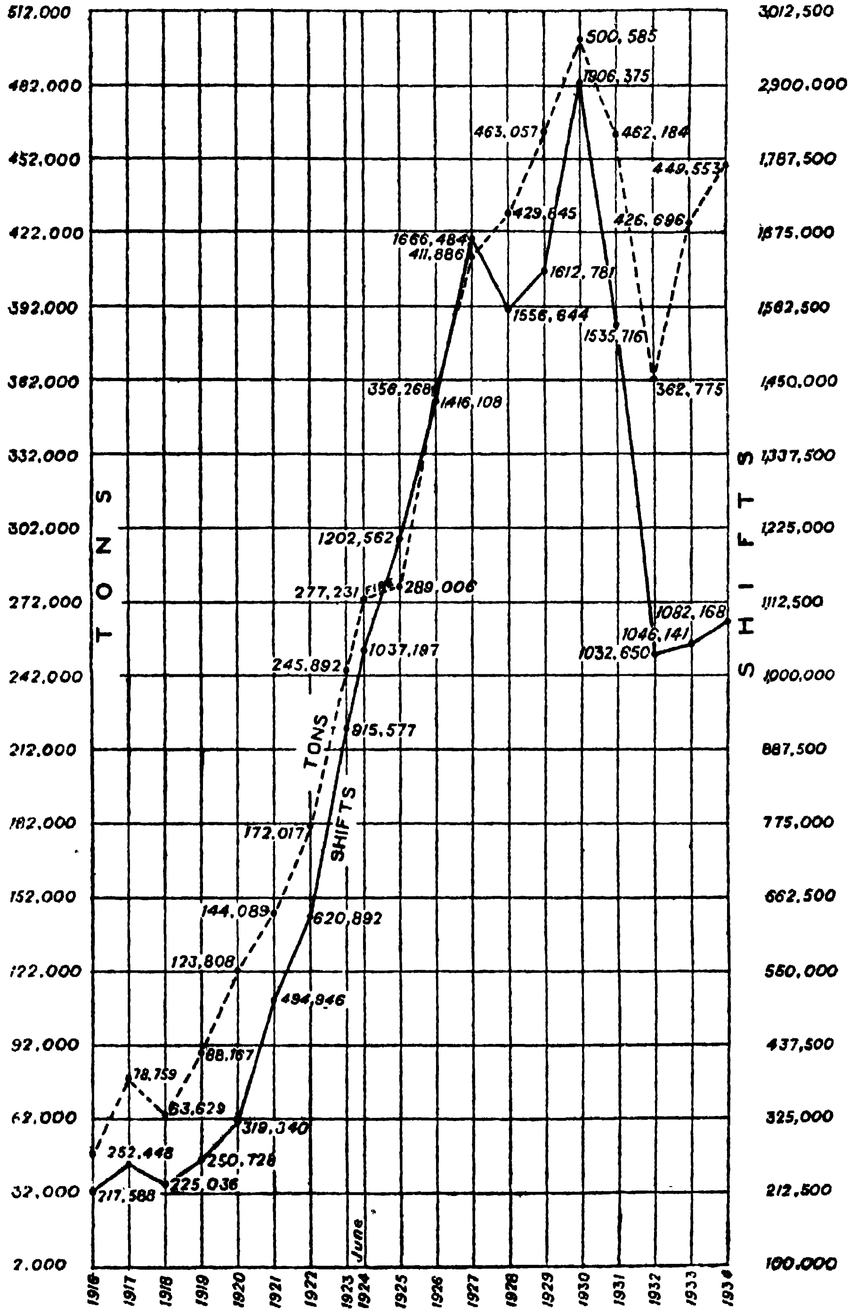

FIG. 11.—*Production of lead-ore and number of shifts worked in the Bawdwin mine since 1916.*

Geology and exploration.

In the neighbourhood of Bawdwin, an ancient series of rhyolitic tuffs, flows, and breccias, with coarse felspathic grits, has been intensely crushed and dislocated by over-thrust faulting. The main ore channel is in this zone, and ascending ore-bearing solutions have metasomatically replaced the congenial materials in the tuffs, giving rise to sulphides along what is known as the Bawdwin fault.

Exploration work along this fault, which runs approximately N.-S., has been carried out over a distance of nearly 7,000 feet and has revealed a length along the strike of 3,400 feet for the great Bawdwin ore-body. This length is in three sections, the Shan (900 feet long), the northern, separated from the Chinaman (1,200 feet long), the middle, by the Yunnan fault which throws the former section 700 feet in a north-easterly direction, while the Chinaman is separated from the Meingtha (1,300 feet long), the southern section, by the Hsenwi fault which has transferred the latter section 1,200 feet to the south-east. The Chinaman and Shan lodes hade to the west and the Meingtha to the east. The Chinaman section which contains the major and minor axes, forms the middle portion of the ore-body and is naturally the largest and richest. The ore-body is confined to the rhyolite tuffs locally designated the Bawdwin tuffs. Underlying these tuffs is a sedimentary bed known as the Yunnan bed, which is unfavourable for mineral deposition. The Yunnan bed, owing to a northerly pitch of the series, is met at successively higher horizons in a southerly direction.

The Chinaman lode, with the exception of a few footwall veins and a small section at the very southern extremity on the upper levels, may be considered to be fully developed by the work completed on Nos. 9, 10 and 12 levels during the period under review. Its width varies from a few feet to over 100 feet, maintaining on some levels an average width of 50 feet of solid sulphides over a distance of over a thousand feet. Writing of this body in 1917, M. H. Loveman[1] says—

'It is primarily a zinc-lead-silver ore-body with small amounts of copper along the edges.'

[1] *Rec. Geol. Surv. Ind.*, XLVIII, pp. 121-178, (1917); and *Trans. Amer. Inst. Min. Eng.*, Vol. LVI, p. 181, (1917).

In 1923, A. B. Calhoun[1] wrote—

'The ore is an intimate mixture of galena and sphalerite and in many places also of chalcopyrite, although the latter is often found in parallel bands alongside the former as pure unmixed chalcopyrite. The mixture of galena and sphalerite contains approximately 1 oz. of silver for every per cent. of lead.'

To quote Mr. Loveman[2] again,—

'A cross section through the Chinaman lode shows a central core of solid zinc-lead ore, with the zinc generally, but not invariably, in excess of the lead. On both sides of this central core are alternating bands of solid ore and mineralised tuff. These bands parallel the main body in strike and dip, but are not persistent themselves, coalescing and pinching out and in reality forming a sort of stockwork. These bands are generally high in lead and comparatively low in zinc. A slight percentage of copper is generally found on their edges. From both sides of these bands the mineralisation extends far out into the tuff, gradually merging into barren rock. Occasional seams and patches of ore are found at considerable distance. There is no sharp boundary between mineralised and unmineralised country rock as a general thing, although this condition is approximated in a few places by fault planes. – – – The extreme richness in metal content of the ore-body is best shown by the fact that a block roughly 800 feet long by 600 feet deep by 30 feet wide contains about 1,750,000 long tons with an average value of approximately Ag. 30 oz., Pb. 31 per cent. and Zn. 29 per cent. A theoretical block of the same size of solid galena and sphalerite with equal amounts of Pb. and Zn. would contain approximately 2,300,000 long tons. Thus the block in the mines is over 75 per cent. solid lead and sinc sulphides. – – – A gradual thinning of the ore body takes place on approaching the underlying sediments.'

Mr. Calhoun sums up his years of experience of the Chinaman ore-body as follows—

'Taken as a whole, the southern end prodominats in zinc-lead ore ; the middle in more equal quantities of both ; and in the northern end the zinc is partly replaced by copper. In practically all sections the ore along the hanging wall is the highest grade, with the lead predominating over the zinc, but towards the centre or the foot-wall the zinc contents increase until, in many sections, the zinc predominates.

Still further towards the foot wall-the ore becomes lower grade and below what is class as ore until it is only mineralised ; the lead however predominates and is often found as pure crystals of galena. – – – There is no definite stoping limit towards the foot-wall side, except what is arbitrarily fixed as the linit of commercial ore (20 per cent. combined lead-zinc with whatever silver it contains). Later, this arbitrary value may be lowered and another 2,000,000 tons of low grade ore added to the reserves.'

Later in 1931, the same authority[3] states,—

'Up to recent years, no rock under 25 per cent. combined lead and zinc sulphides with accompanying silver was considered profitable ore, but during the

[1] *Trans. Amer. Inst. Min. Eng.*, Vol. LXIX, p. 211, (1923).
[2] *Op. cit.*, Vol. LVI, p. 183, (1917).
[3] *Min. Mag.* XLIV, p. 329, (June, 1931).

last two years this has been lowered to 16 per cent. The total ore as developed and extracted in the entire ore-body to date is as follows :—

—	Tons.	Ag. oz.	Pb. per cent.	Zn. per cent.	Cu. per cent.
Developed	7,881,768	21·4	25·1	15·2	0·96
Extracted	3,616,103	22·6	24·7	15·0	1·05
Total ore reserve in the Mine .	4,265,665	20·4	25·5	15·3	0·88

As a result of work concluded in Nos. 8, 9, 10 and 11 levels, the Shan lode, which is about 20 feet in average width and contains high grade copper in addition to lead-zinc sulphides was completely developed during the period under review, whilst the Meingtha lode which provided the most profitable discovery of the period was developed on all levels down to No. 9. The Meingtha lode yielded :—

Tons.	Ag. ozs.	Pb. per cent.	Zn. per cent.	Cu. per cent.
964,499	15·3	19·5	12·1	1·05

Some of this ore is high in copper and contains nickel and cobalt as arsenides, which are recovered with the copper minerals by flotation.

The new copper ore-body called the Chin lode (formerly the Gold hole) was connected to the main underground workings on No. 1 level and is now being systematically developed. The ore-body, from which fine specimens of native copper are obtained, is a flat-lying copper vein in rhyolite. It is situated to the north of the Shan lode but does not lie within the Bawdwin fault.

Prospecting has been carried out in the Bawdwin fault beyond the limits of the ore-body. To the south the fault was followed on No. 6 level to co-ordinates 4656 S[1], where overlying sediments were encountered. To the north, on the same level, the vein was followed in tuff and rhyolite to co-ordinate 1906 N. Here the vein was found to be small and of non-commercial ore. It is proposed to continue this drive another 2,000 feet at least if the rhyolite continues, as there are barite deposits on the surface which may indicate the existence of other commercial ore bodies.

[1] Zero datum—Marmion shaft.

The mine was originally worked by the Yunnanese Chinese, probably for hundreds of years, and abandoned by them in the sixties of last century, when their galleries reached permanent underground water-level and the Mahomedan revolt in Yunnan rendered their tenure amongst the Kachin tribes insecure. Modern development commenced in 1902 after the attention of Europeans had been drawn to the vast heaps of lead slags left by the Chinese from their silver-smelting operations. In 1909, the first production of lead and silver from the old slags was made. Early mining exploitation was not encouraging but after the discovery of the remains of a large ore-body in the 'Dead Chinaman' tunnel in 1912, development has been active and successful and the many thousands of feet of driving, cross-cutting, and rising have now proved the Chinaman lode to be one of the largest and richest silver-lead-zinc ore-bodies in the world.

Mining and development.

The ore-body was originally attacked by sinking a vertical shaft in the Bawdwin valley, but once the potential riches of the deposit were realized, a commencement was made in opening up at deeper levels, by driving Tiger tunnel from a point nearly two miles away. This is 653 feet below the zero-level at Bawdwin, is double-tracked from the portal to the Marmion shaft and is 9 feet by 8 feet inside measurement. It corresponds to the No. 6 level of the mine and is the main haulage and drainage level. All the ore, as it is mined, is raised or lowered to this level and hauled out by electric locomotives to the tipple plant and storage bins at Tiger camp. As originally driven, the Tiger tunnel was within the Chinaman ore-body at the mine end and was therefore liable to damage resulting from mining operations in the lode itself. A diversion tunnel lined with masonry was accordingly driven in the country-rock on the east side of the Chinaman ore-body and connected up to cross-cuts in the lode so as to prevent any chance of transport being interrupted through movements in the ore-body. The replacement, in Tiger tunnel, of timber by masonry has also been carried out.

Another most important piece of work has been the sinking of a large, vertical, circular shaft known as the Marmion shaft in the country rock on the west side of the Shan lode. The shaft is lined with masonry and equipped with steel-work for guiding cages. During the period under review this shaft was sunk a further 536

feet to a total depth of 1,606 feet, *i.e.*, 154 feet below No. 12 level. The masonry lining and steel work were completed and the skip cages operated to No. 12 level and the big cage to No. 11 level. A diamond-drill hole was bored from the bottom of the shaft to a depth of 1,955 feet below the surface, and proved the existence of a total thickness of 700 feet of unfavourable sediments at this point.

Other developments which have been carried out during the period under review are as follows:—

		Feet.
(1)	Shaft sinking	536
	Driving	32,960
	Cross-cutting	40,742
	Rising	1,106
	Winzing	2,191
	Diamond drilling	1,753
	TOTAL	79,288

(2) A skip-loading pocket was made for the Marmion shaft below No. 8 level, 14,220 cubic feet of rock being excavated and the space lined with reinforced concrete. The gates for the storage bins and the four-ton measuring hoppers are operated by compressed air.

(3) A skip-dumping pocket was also made just below No. 5 level and consists of two compartments lined with reinforced concrete. The dumping gear, which can be put in and out of action in order to dump the skip or let it go through to the surface, is electrically-operated (remote control) by the hoisting engineer on the surface.

(4) Double-deck cages with 4-ton skips (underslung) were put in operation on November 19, 1930, hoisting ore from the No. 8 pocket and have proved very efficient and highly satisfactory.

(5) A complete electric signal system, both visible and oral, was installed in Marmion shaft. It consists of a 17-core cable, with junction boxes, pull switches, buzzers and indicating lamps on all levels.

(6) On No. 10 level, a pumping station, consisting of two Rees Roturbo multi-stage pumps, each 750 G. P. M. against a head of 582 feet, driven by a 192 B. H. P. slip ring motor, was completed and has been used since June, 1930.

(7) Two battery locomotives (2½ tons and 1½ tons respectively) were placed on No. 8 level hauling ore from north and south to the Marmion shaft ore pocket. They handle 400 to 500 tons per day and are both efficient and economical.

(8) All hand-trammed cars in the mine have been equipped with either roller- or ball-bearings.

(9) An Osano-type scraper-loader with a double drum air-hoist and several smaller scrapers operated by Little Trugger air-hoists were tried but were not found to be of any decided advantage in small drives when using cheap labour.

(10) Innovations are the uses of old railroad steel for drive sets instead of the more expensive timber ones and galvanized wire netting (3′ wide, 3″ mesh, gauge 13) in place of 8″×2″×6′ lagging for lining up the sides of stopes.

(11) The last of the fire area, the section south of 1,500 on the upper levels, was completely recovered in 1929.

(12) Diamond drilling has been used for prospecting the sedimentary beds in the bottom of the Chinaman and Shan lodes, and has been found to be slow, difficult and costly because of the physical characteristics of the friable rock which will not core.

(13) The mine recovery co-efficients based on the extraction of all ore mined up to January 1934, totalling 4,906,517 tons, show that there will be a recovery of at least the tonnage of metals shown in the reserve, but in a larger tonnage of ore than estimated, because of stoping outside the hypothetical lines drawn from the result of cross-cut sampling.

(14) Costs have been materially reduced and efficiency increased during the period.

Southern Shan States.

In the last quinquennial review, reference is made to the small quantities of lead-ore which continued to be raised in the Southern Shan States at Bawzaing in the vicinity of Mawson, a village lying about 18 miles north of Heho on the Southern Shan States branch of the Burma Railways and also to the shipment of old Chinese slags from the same area. No shipment of slags took place during the present quinquennium whilst the output of lead-ore from Bawzaing, which had increased from 375 tons in 1926 to a maximum of 1,151 tons in 1928, declined to 719 tons in 1929 and 305 tons in 1930. Thereafter the mine was closed down, being unable to work at a profit at the low prices prevailing for lead. The ore reserves in sight in April, 1930 were officially placed at 185,400 tons understood to average more than 7 per cent. lead. Dr. Coggin Brown[1] has described this mine in a paper on the Lead Ore Deposits of Mawson. With reference

[1] *Rec. Geol. Surv. Ind.*, LXV, p. 394, (1931).

TABLE 58.—*Production of Lead-ore during the years 1929 to 1933.*

	AVERAGE 1924-28.			1929.		
	Quantity.	*Value.*		Quantity.	*Value* (£1 = Rs. 13·4).	
	Tons.	*Rs.*	£	Tons.	*Rs.*	£
Burma—						
Northern Shan States	372,798	(a) *2,24,88,334*	1,668,094	463,972	(a) *2,50,00,613*	1,865,717
Southern Shan States	5,088	*75,138*	5,588	719	*66,590*	4,969
Yamethin	9	*152*	26	..	..	..
Rajputana—						
Jaipur State	1	*494*	37	5	*1,500*	112
TOTAL	**377,896**	*2,25,64,118*	1,673,745	**464,696**	*2,50,68,703*	1,870,798

	1930.			1931.		
	Quantity.	*Value* (£1 = Rs. 13·5).		Quantity.	*Value* (£1 = Rs. 13·5).	
	Tons.	*Rs.*	£	Tons.	*Rs.*	£
Burma—						
Northern Shan States	529,814	(a) *1,85,04,616*	1,370,712	397,679	(a) *1,28,88,270*	954,687
Southern Shan States	305	*21,425*	1,587	..	..	..
Yamethin	..	..	..	..	..	..
Rajputana—						
Jaipur State	5	*650*	48	..	..	..
TOTAL	**530,124**	*1,85,26,691*	1,372,347	**397,679**	*1,28,88,270*	954,687

	1932.			1933.			AVERAGE 1929-33.		
	Quantity.	*Value* (£1 = Rs. 13·3).		Quantity.	*Value* (£1 = Rs. 13·3).		Quantity.	*Value.*	
	Tons.	*Rs.*	£	Tons.	*Rs.*	£	Tons.	*Rs.*	£
Burma—									
Northern Shan States	372,586	(a) *1,09,95,587*	826,736	454,791	(a) *1,15,61,915*	869,317	443,768	*1,57,90,200*	1,177,434
Southern Shan States	..	..	..	..	..	..	205	*17,603*	1,311
Yamethin	..	..	..	..	..	..	..	..	..
Rajputana—									
Jaipur State	..	..	..	..	..	..	2	*430*	32
TOTAL	**372,586**	*1,09,95,587*	826,736	**454,791**	*1,15,61,915*	869,317	**443,975**	*1,58,08,233*	1,178,777

(a) Value of lead extracted.

to the origin of the ores Dr. Brown, after summarising the opinion of previous writers on the subject, gives his tentative opinion—

'that the Bawzaing deposits have more in common with those world-wide deposits of lead ores in sedimentary rocks that have apparently had an origin independent of igneous activity rather than with others that are believed to be directly connected with igneous sources.'

He mentions that amongst their characteristics are—

'their occurrence in brecciated zones of limestone and associated rocks and in pipes and channels.'

and that—

'to some though still unknown extent they are of metasomatic origin for the galena certainly occurs at times disseminated in limestones.'

Yamethin.

A small output of lead ore was reported from the Yamethin district of Upper Burma, during the years 1925 and 1926 in the last quinquennium. This was probably from prospecting work in the locality opened up by the Mount Pima Mining Company in 1908-09. The latter venture did not prove a success and as no output of lead is reported from Yamethin during the period under review one concludes that the 1925-26 venture shared a like fate.

Indian locality.

A small quantity of lead figured in the mineral returns for 1925 and 1926 from Jaipur State. During the present quinquennium a return of 5 tons for each of the years 1929 and 1930 is reported.

We are greatly indebted to Messrs. The Burma Corporation, Limited, for all the details given in this article regarding the Bawdwin mine.

Magnesite.

[L. L. FERMOR.]

Salem district.

The 'Chalk Hills' lying between the town of Salem and the Shevaroy Hills in Southern India derive their name from the general effect of the network of white magnesite veins, which are prominent over an area of about 4½ square miles. The occurrence was well known early in the last century, when Mr. J. M. Heath, then 'Commercial Resident'(Collector) at Salem on behalf of the East India Company, was an energetic prospector. The area was described by W. King and R. Bruce Foote in 1864[1] and the origin of the magnesite by alteration of dunite (olivine-rock) was first noticed in 1892.[2] A more complete account of the area with map and photographs was published in

[1] *Mem. Geol. Surv. Ind.*, IV, p. 312-17.
[2] T. H. Holland, *Rec. Geol. Surv. Ind.*, XXV, p. 144, footnote.

1896 by C. S. Middlemiss,[1] who drew special attention to the large quantities of mineral easily available. The network of magnesite veins is seen piercing two great intrusive masses of serpentinised ultra-basic rocks. Over an area of about 130 acres the volume of magnesite was estimated to be from ½ to ⅓ of the total rock volume. Over an area of 1,140 acres, the volume was reckoned to be from ⅛th to $\frac{1}{10}$th. Of the quantity present in the thin veins and patches in the rest of the area, no opinion has been expressed, but Mr. Middlemiss regards the amount of magnesite in these hills as 'practically unlimited.' According to Sir Thomas Holland's view of the origin of this mineral, its formation is not a mere superficial phenomenon, and it may be expected to extend to considerable depths. Dr. J. Coggin Brown[2] describes the compact vein magnesite of India as a hard, white, brittle mineral, closely resembling unglazed porcelain and breaking with a conchoidal fracture; its crystalline structure is not visible to the naked eye.

Through the enterprise of Mr. H. G. Turner, the Magnesite Syndicate, Limited, was formed to develop the deposits. A paper by Mr. H. H. Dains[3] demonstrated the high quality of the material obtainable, the percentage of magnesium carbonate in ordinary samples being from 96 to 97 and in picked samples 99. The following analyses have been made on fair samples :—

	Blount.	Dains.	Pattison (cargo sample).	Ferguson.	
				1	2
Silica	0·22	0·29	1·17	0·31	1·70
Iron oxide	0·30	0·65	0·14	0·40	0·65
Alumina				1·10	0·10
Manganese oxide	..	0·20	0·06	..	..
Lime	*nil*	0·83	0·78	..	..
Magnesium oxide	47·35	46·42	46·28	97·80	97·40
Carbon dioxide	51·44	50·71	50·10		
Water	0·27	0·16	1·30	0·60	traces
Sulphuric acid	..	..	0·03	..	..
Phosphoric acid	..	..	0·01	..	..
TOTAL	99·58	99·26	99·87	100·06 (*a*)	99·85
Magnesium carbonate	98·79	97·13	96·34	97·80	97·40

(*a*) Including 0·85 calcium carbonate.

[1] *Rec. Geol. Surv. Ind.*, XXIX, p. 31, (1896).
[2] *Bull. Ind. Indust. and Labour*, No. 3, p. 2, (1921).
[3] 'The Indian Magnesite Industry.' *Journ. Soc. Chem. Industry*, XXVIII, p. 503, (1909).

The mineral is won by open quarrying operations and is calcined on the spot to produce (*a*) highly calcined or caustic magnesia, obtained at a temperature of about 800° C., and (*b*) dead-burnt, sintered, or shrunk magnesia, obtained by calcination at about 1,700° C. Roughly speaking 2 tons of the crude mineral yield a little less than 1 ton of caustic magnesia, while about 2½ tons are requisite for the manufacture of 1 ton of dead-burnt magnesia. The following is a statement of average analyses kindly supplied by the Magnesite Syndicate, Limited :—

	Crude magnesite.	Lightly calcined magnesia.	Dead-burnt magnesia.
	Per cent.	Per cent.	Per cent.
Silica	1·86	3·39	3·59
Iron oxide and alumina	0·08	0·14	1·07
Lime	0·81	1·48	1·02
Magnesia	46·41	93·18	92·13
Loss on ignition	50·64	1·81	0·15
Moisture	0·20	..	..

$MgCO_3$ equivalent—97·05 per cent.

The following table shows the amount of calcined magnesia manufactured during 1929-1933 :—

	Tons.
1929	8,405
1930	7,498
1931	4,406
1932	4,774
1933	3,167

These figures include the output of a specially burnt magnesite which is being used for furnace hearths in steel works in the United Kingdom.

The exports of calcined magnesia during this period averaged 4,989 tons annually and of crude magnesite only 212 tons. The latter figure is so small because even with a 10 per cent. Imperial

preference in the United Kingdom in favour of Empire magnesite, the company is unable to compete in the market for crude magnesite, although the quarries are equipped for a production of 50,000 tons of crude magnesite annually.

Experiments made on a considerable scale on behalf of Mr. H. G. Turner[1] showed that when highly heated in an electric furnace the Salem magnesite yields a hard dense crystalline mass of the greatest refractory quality. Salem magnesite has been used in Norway and England for the production in an electric furnace of fused magnesite and dead-burnt magnesia.

Other occurrences.

Magnesite is known to occur at several other places in southern India, always as veins traversing peridotites, for example at Seringala in Coorg, on the Cauvery above Fraserpet, in other parts of the Salem district,[2] in the Trichinopoly district, and in the Hassan and Mysore districts of Mysore.[3] In 1923, the Tata Iron and Steel Company acquired magnesite properties in the Mysore district with a view to producing refractory materials for their furnace at Sakchi. The output in the Mysore State amounted to 4,114 tons in 1919, 3,046 tons in 1920 and 2,865 tons in 1921. The production declined to 856 tons in 1922, and 100 tons in 1923, the decrease being due to the temporary closing down of the mines worked by the Tata Iron and Steel Company, Limited. These mines were re-opened during the quinquennium under report and produced in 1924 34 tons, in 1925 *nil*, in 1926 1,785 tons, in 1927 2,672 tons and in 1928 1,864 tons. During the present quinquennium, the output of magnesite from Mysore fell to 355 tons in 1931 and rose sharply to 4,075 tons in 1933 with an annual average of 1,425 tons for the period. The whole of this output is despatched to Jamshedpur for use by the Tata Iron and Steel Company. Some of it is dead-burnt at Jamshedpur and some sent to Messrs. Burn & Co. at Raniganj for conversion into magnesite bricks for use at Jamshedpur. In addition, the Tata Iron and Steel Company still imports annually about 500 tons of magnesite and 40,000 magnesite bricks from Austria.

According to the late Mr. A. Ghose, large quantities of magnesite, although of inferior quality, occur in association with the

[1] *Journ. Iron and Steel Inst.*, No. 1 of 1904, pp. 498-99.
[2] W. King and R. B. Foote, *Mem. Geol. Surv. Ind.*, IV, pp. 318-324.
[3] A. Primrose, *Rec. Mysore Geol. Dept.*, III, p. 239; IV, p. 178. V. S. Sambasiva Iyer, *op. cit.*, V, p. 61. Annual Reports of the Chief Inspector of Mines in Mysore.

TABLE 59.—*Production of Magnesite during the years 1929 to 1933.*

	1929		1930		1931		1932		1933		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Madras—												
Salem .	22,134	*1,08,722*	15,563	*67,978*	4,978	*21,540*	13,492	*64,482*	11,131	*67,557*	13,459	*66,056*
Mysore State—												
Mysore .	1,363	*23,471*	960	*16,761*	355	*5,808*	372	*8,273*	4,075	*30,123*	1,425	*16,887*
TOTAL .	23,497	*1,32,193*	16,523	*84,739*	5,333	*27,348*	13,864	*72,755*	15,206	*97,680*	14,884	*82,943*
Total value in Sterling.	..	*£9,865* (£1 = Rs. 13·4)	..	*£6,277* (£1 = Rs. 13·5)	..	*£2,026* (£1 = Rs. 13·5)	..	*£5,470* (£1 = Rs. 13·3)	..	*£7,344* (£1 = Rs. 13·3)	..	*£6,196*

steatite deposits of Muddavaram and Musila Cheruvu in the Karnul district (*see* page 445).

Uses of magnesite.

Magnesite has many applications, of which its use as a refractory material is the most important. Carbon dioxide in the liquid form has not so far been recovered from the Salem deposits in India. The question is largely one of fuel, freights and markets. Salem is some 200 miles from Madras, and the transport of liquid carbon dioxide would involve freight both ways on heavy steel cylinders. The manufacture of solid carbon dioxide requires an elaborate plant and considerable power.

Of the two commercial varieties of magnesite, the caustic or calcined, which should contain about 94 per cent. of magnesia and carbon dioxide, 'slacks' when exposed to the air. Before the war, practically the whole of the calcined magnesia of Salem was shipped to Europe for use in the preparation of 'oxy-chloride' or 'Sorel' cement, used in the manufacture of artificial stone, floorings, fire-proof partitions, abrasive wheels, files, etc. This cement is formed by mixing caustic magnesia with a solution of magnesium chloride and will carry up to 20 parts of sand for one of magnesia. Owing to the scarcity of European supplies during the war, large quantities of magnesite, in the years 1916-17, were shipped to the United Kingdom from Salem. The attached Table 59 shows the Indian production during the period under review. The average annual production during 1919-1923 amounted to 18,039 tons, valued at Rs. 2,15,788; during 1924-1928 it rose to 25,717 tons valued at Rs. 2,90,376, with a record production in 1926 of 30,461 tons valued at Rs. 3,54,355; whilst during 1929-1933 it fell to 5,333 tons in 1931, with an average for the period of 14,884 tons valued at Rs. 82,943.

Dead-burnt magnesia contains less than ½ per cent. carbon dioxide, and should average at least 87 or 88 per cent. of magnesium oxide. The Indian material is always considerably higher in grade. The most objectionable impurity is lime, and here again the Indian commodity excels. The dead-burnt form is a very inert material not easily affected even by extreme heat. Its main use is as a refractory lining for steel furnaces, and in this way the magnesite industry is closely bound up with that of iron and steel. In the basic open-hearth process, about 6 lbs. of magnesite are required for every ton of steel made. Something like 90 per cent. of the

total output of magnesite is employed for this purpose alone in the United States. Refractory magnesia is also employed in lead, copper and other smelters. The greater proportion of magnesite produced is utilised in a dead-burnt form.

Other uses for magnesite are the preparation of medicinal compounds, and the manufacture of certain varieties of vitreous porcelain, of fire-resisting paints, of non-conducting materials for steam-pipe and boiler laggings, and of sulphite paper pulp.

The chief competing sources of supply are Austria, Russia, the United States, Greece and Czechoslovakia. The Austrian material, with its higher iron content, makes a satisfactory lining for steel furnaces, and is, for this reason, in demand by the iron and steel industry. Greece exports both crude magnesite and calcined magnesia. The Indian material approaches closer to the Grecian type than to the Austrian, and before and after the war the Indian exports have been required more for the manufacture of cements and similar products than for refractory linings. During the war, ferric oxide was added to the Indian magnesite in order to produce a dead-burnt commodity suitable for metallurgical purposes; this plan deserves further investigation. There are immense stores of the double chloride of potassium and magnesium known as carnallite in the saline deposits of Stassfurt in Prussia, and several processes have been patented for utilising the waste magnesium chloride liquor obtained as a bye-product in the manufacture of calcium chloride. Magnesium oxide is also obtained from dolomite by calcination at 900° C. followed by lixiviation with ammonium chloride and potassium chloride.

The greatest consumers of magnesite are the steel-producing countries, Germany, United States, Great Britain and France, and a large percentage of the Indian exports go to the first three countries. The United States, besides being importers, also possess large deposits of their own in Washington where it is dead-burnt, and much smaller deposits in California where the material is practically all lightly calcined. As the world's supplies of magnesite are, from a practical point of view, far greater than the demand is ever likely to be, its successful development is largely a matter of geographical position and available markets. A demand in this country for artificial stone products in the form of flooring, tiles, partitions, etc., would stimulate an industry capable of large expansion.

Manganese.

[L. L. FERMOR.]

Progress of the industry.

An earlier review records the rapid development of the manganese-quarrying industry in India during the early years of the present century, the zenith being reached in 1907 with an output of 902,291 tons of ore, and in 1908 India took for the first time the lead amongst the world's producers of manganese-ore, hitherto held by Russia. Since 1905 the industry has maintained a position of comparative stability until the present quinquennium, when the nadir of depression has been reached. It is therefore of interest to summarise briefly the data of successive quinquennial periods. The facts of the pre-war quinquennial period 1909-1913 are that the average annual production was 712,797 tons, whilst the exports for the official years 1909-10 to 1913-14 averaged 694,283 tons annually.

The next quinquennial period, 1914-1918, coincided approximately with the period of the war, and was marked by controlled and restricted exports, the control being due to the necessity of ensuring that a mineral of such importance to the iron and steel industry should not reach enemy countries either directly as ore or in the form of alloys, iron, or steel, whilst the restrictions were due to the well-known shortage of shipping. In spite of these adverse factors the Indian production during the quinquennium 1914-1918 averaged 577,457 tons annually; but the exports for the official years 1914-15 to 1918-19 averaged only 491,558 tons, with a resultant accumulation in India during the period of over 300,000 tons of stocks, after allowing for ore railed to Sakchi and Kulti for use in the Indian iron and steel industry, this accumulation being due in part to the acute shortage of shipping during 1917 and 1918.

During the post-war quinquennium, 1919-1923, the Indian production averaged 624,635 tons annually, whilst the exports during the official years 1919-20 to 1923-24 averaged 681,972 tons, the excess of exports over production indicating a reduction of stocks to the extent of nearly 400,000 tons during the period, after allowing for ore railed to Tatanagar, Kulti, and Burnpur (*see* Table 80), for use in the iron and steel industry of India. This increase in both production and exports as compared with the war period

was not, however, due to a return to pre-war conditions, but marked the balance of beneficial factors in favour of India.

During the quinquennium 1924-1928, the Indian production averaged 953,039 tons, whilst the exports during the years 1924-25 to 1928-29 have averaged 759,104 tons, with a resultant accumulation of over 780,000 tons of stocks, after allowing for consumption by the Indian iron and steel industries. Nevertheless, both production and exports were much in excess of the figures for the previous quinquennium, and these increases, in spite of increasing competition with supplies from other countries, were taken as a measure of the expansion of the world's iron and steel industry with a return to relatively normal conditions.

The quinquennium now under review, 1929-1933, opened with the highest world's production of pig-iron and steel yet recorded, namely 97·2 million tons of pig-iron and ferro-alloys, and 118·3 million tons of steel in 1929. The world's output of manganese-ore, however, increased in a still greater proportion to 3,598,343 tons, and consequently there was a serious fall in the price of manganese-ore per unit to 14·0*d.* This was really the last prosperous year for the manganese industry, and during the next three years the world's production of iron and steel slumped to 38·9 million tons of pig-iron and ferro-alloys and 49·7 million tons of steel in 1932, when the world was at the nadir of depression. The world's production of manganese-ore by then had fallen to 1,218,879 tons, the Indian share being only 212,604 tons, or 17·4 per cent. against 29·6 per cent. to 56·6 per cent. during the period 1923 to 1928, with the price per unit of manganese at 9½*d.* The full magnitude of the disaster that had overtaken the Indian manganese industry is perhaps best realised from the fact that whilst the quantity of the production in 1932 was a little over one-fifth of that of the peak year of 1927, the value was less than one-nineteenth of the value of the 1927 production. The result of these low prices was that in the Central Provinces, by 1932, the great majority of the mines were closed, including several mines, such as Kandri and Balaghat, that had never been closed since the commencement of work in 1900 and 1901. One of the principal companies, the Central India Mining Company, went into liquidation in 1929, but this was due to the increasing difficulty of recovering ore at remunerative prices, and preceded the slump. Many of the smaller workers did not produce any ore during the quinquennium. In 1933

there has been a slight world recovery and pig-iron and steel production have risen respectively to 48·4 million tons and 66·7 million tons, and the world's manganese-ore production to 1,745,000 tons. The increase in the Indian production was, however, trivial, namely to 218,307 tons, so that the Indian percentage of the world's total was still lower, at 12·5 per cent. The average total output of manganese for the whole of India during the quinquennium 1929-1933 was 558,596 tons as compared with 953,039 tons in the previous quinquennium. The exports during the quinquennium in question did not fall off quite so disastrously as the production, the exports for the years 1932 and 1933 being respectively 301,252 tons and 376,354 tons, the average for the quinquennium being 566,616 tons against 759,360 tons in the previous quinquennium.

In view of the world depression it is not surprising that the steady fall in the price of manganese-ore *c.i.f.* U. K. ports from 22·9*d.* per unit in 1924 to 17·0*d.* in 1928 that characterised the previous quinquennium continued at an accelerated pace during the quinquennium under review, namely from 14·0*d.* in 1929 to 9·5*d.* in 1933, the last price being nearer to the pre-war minimum of 9*d.* in spite of the continued higher cost of wages, railway freights, etc. During the quinquennium the average freight rates per ton of manganese-ore from Calcutta and Bombay to United Kingdom ports fell from £0-19*s.*-2*d.* in 1929 to £0-14*s.*-3*d.* in 1933, so that the average *f.o.b.* price Indian ports fell from 8·80*d.* in 1929 to 5·24*d.* in 1932 with a slight rise to 5·48*d.* in 1933. That the Indian manganese industry has taken more than its fair share of the decrease due to the world depression is shown by the fact that the Indian proportion of the world's total production, which varied from 32 to 38 per cent. in the previous quinquennium, fell from 27·6 per cent. in 1929 to 12·5 per cent. in 1933 during the quinquennium under review. But whereas during the previous quinquennium the total production for the quinquennium was 969,675 tons in excess of exports, during the quinquennium 1929-1933 the excess was only 63,986 tons, showing a much better adjustment of the production to export requirements. As the iron and steel companies in India consumed 204,157 tons of manganese-ore during the quinquennium, of which 21,715 tons represented stocks carried over from the previous period giving a consumption of 182,442 tons of ore produced during the quinquennium, the exports during the quinquennium *plus* internal

consumption exceeded production by 118,456 tons, so that the slump must have paradoxically led to an improvement in the stock position of ore for export from India equivalent to this amount. This result is due, of course, to the fact that so many mines were closed, so that export requirements were partly met from stocks. The position during the quinquennium has not been complicated by any large variations in the exchange value of the rupee such as marked the period 1919-1923, the range being from 1*s.* 5$\frac{13}{16}$*d.* in 1930 to 1*s.* 6$\frac{1}{16}$*d.* in 1933. Most of the data discussed above are summarised in Table 60.

In the previous review, it was noted that with falling prices and world over-production, the period ended with decreasing business and decreasing profit for Indian producers, leading to curtailment of production, and a search for means of reducing costs, which had already led to requests for reduced railway freights from the mines to the ports. During the present quinquennium, as already noted, the continuance of these tendencies, accentuated by the world depression, has led to the closing of many mines, with a flicker of improvement in 1933. The new port of Vizagapatam has been opened during the quinquennium, reducing the lead from the Central Provinces to the sea and enabling a certain amount of second-grade ore to be exported, where otherwise this would have been impossible. Certain reductions in railway freights have been introduced, but they are not commensurate with the great fall in the world prices of manganese-ore. If India is to be able to compete in the future in the world's markets as successfully as in the past, then every item in the bill of costs will have to be brought down to figures approximating to those prevailing before the war, as long as the price of manganese-ore is on a pre-war basis, which is likely to be for a long time. This means that the Indian manganese industry needs greater reductions in railway freights than have yet been conceded.

Of foreign producers, Russia occupied the leading position up to 1907, and in 1912 to 1915; but subsequently the circumstances of war and, later, internal troubles caused the practical stoppage of the industry, so that production fell from 1,234,900 tons in 1913, to 56,200 tons in 1919, since when the industry has completely recovered. The history of the 20 years' concession over the Georgian manganese-ore deposits granted in 1925 by the Soviet Government to Messrs. W. A. Harriman & Co. of New York, and

of the failure of the American enterprise in 1928, has been referred to in the previous quinquennial review. The present position is that these deposits are now worked by the Soviet Government, and that as a result of the improvement of transport facilities and in the methods of work, including the installation of up-to-date washing plants introduced by the Americans, the output from Russia (Nikopol) and Georgia rose from 420,084 tons in 1924, to 1,012,362 tons in 1926, after which production fell to 830,228 tons in 1927, and 661,801 tons in 1928. These figures are in terms of washed ore, except for the small production from the Urals, which is crude ore. During the present quinquennium the Russian output rose to 1,543,362 tons in 1930, by far the highest figure yet recorded, to fall to only 813,000 tons in 1932. Russia resumed the leading position in 1929 at the expense of India, and under present conditions it is evident that it is very difficult for India to compete with Russian ore in most markets.

The disappearance of Russia from Allied markets during the war was not of very serious moment to the Allies, as it coincided with the isolation of one of the chief consumers of the world's supplies of manganese-ore, namely Germany, who before the war imported large quantities from both India and Russia. Such shortage as resulted was felt chiefly in the United States, owing partly to the difficulty of arranging shipping from India, and led to a great development in the manganese industry of Brazil, which, as will be seen from Plate 6, rose from third to second place amongst the world's producers, concurrently with India's resumption of first place. The exports of Brazil were taken almost entirely by the United States, not only to replace former imports from Russia and India, but also to balance a great reduction in the imports of ferro-manganese. On account, however, of the great increase in the activity of the American iron and steel industry for the provision of munitions of war, supplies of manganese-ore were still inadequate, with the result that all known occurrences of manganese-ore in the United States of America were investigated, of whatever grade, so that the output of manganese-ores containing 40 per cent. manganese or over rose from 2,635 tons in 1914, to 129,405 tons in 1917, and of ores containing over 35 per cent. manganese to 305,869 tons in 1918. At the same time the output in the United States of America of ores carrying less than the above percentages of manganese rose from 98,265 long tons in 1914, to 1,170,462 long tons in

TABLE 60.—*World's production of pig-iron, steel and manganese-ore, 1913 to 1933, with prices, freights and rates of exchange.*

Year	Iron and steel industry—World's production.		Manganese industry.							
	Pig-iron and ferro-alloys.	Steel.	World's production.	Indian production.	India's percentage of total.	Average price per unit of manganese *c.i.f.* U. K. ports.	Average freights per ton from Calcutta and Bombay to U. K. ports.	Corresponding price per unit *f.o.b.* Indian ports.	Indian exports: official years.	Average exchange value of the rupee.
	Millions of tons.	Millions of tons.	Long tons.	Long tons.	Per cent.	*Pence.*	£ *s.* *d.*	*Pence.*	Long tons.	*s.* *d.*
1913 . .	77·5	74·8	2,284,203	815,047	35·7	11·12	0 19 5½	6·15	804,796	1 4
1914 . .	59·1	59·4	1,841,479	682,898	37·1	10·17	0 17 9	5·75	506,982	1 4
1915 . .	59·4	65·0	1,393,479	450,416	32·3	20·17	2 1 6	9·6	473,893	1 4
1916 . .	72·4	76·7	1,613,050	645,204	40·0	30·7	4 1 8	10·5	652,199	1 4
1917 . .	65·9	80·3	1,863,549	590,813	31·7	37·7	5 11 8	10·3	437,655	1 4
1918 . .	64·4	75·4	1,751,698	517,953	29·6	42·5	6 3 0½	12·37	387,061	1 5[illegible]
1919 . .	50·9	56·2	1,163,918	537,995	46·2	29·6	3 11 0	11·96	382,116	1 8[illegible]
1920 . .	60·4	68·9	1,718,689	736,439	42·8	45·5	4 9 4	23·46	805,839	2 0[illegible]
1921 . .	36 5	41·1	1,199,490	679,286	56·6	17·6	1 5 0	11·00	530,371	1 4[illegible]
1922 . .	50·1	63·1	1,311,360	474,401	36·2	13·9	0 19 2	8·70	877,194	1 3[illegible]
1923 . .	67·8	75·5	1 680,434	695,055	41·4	21·2	1 1 4	15·48	814,342	1 4[illegible]
1924 . .	65·8	75·0	2,109,354	803,006	38·1	22·9	1 2 8	16·86	639,210	1* 5¼
1925 . .	75·7	88·8	2,657,447	839,461	31·6	21·6	1 0 11	15·98	564,225	1 6[illegible]
1926 . .	77·8	91·5	3,184,382	1,014,928	31·9	18·4	1 0 3	12·94	536,214	1 5[illegible]
1927 . .	85·6	100·0	3,243,905	1,129,353	34·8	18·1	0 19 5	12·84	703,949	1 5[illegible]
1928 . .	87·9	107·9	2,939,337	978,449	33·3	17·0	0 17 5	12·22	680,938	1 5[illegible]
1929 . .	97·2	118·3	3,598,343	914,279	27·6	14·0	0 19 2	8·80	815,673	1 5[illegible]
1930 . .	79·0	93·4	3,585,847	829,946	23·1	13·1	0 18 0	8·18	485,773	1 5[illegible]
1931 . .	54·7	68·4	2,240,844	537,844	24·0	11·7	0 14 4	7·66	211,737	1 5[illegible]
1932 . .	38·9	49·7	1,218,879	212,604	17·4	9·5	0 15 3	5·24	197,730	1 6[illegible]
1933 . .	49·4	66·7	1,745,000	218,307	12·5	9·5	0 14 8	5·48	266,101	1 6[illegible]

1918. To allow for the use of these lower grade ores not only was the composition of standard ferro-manganese in the States reduced from 80 per cent. to 70 per cent. manganese, but many American smelters had to adapt their practice to the use of spiegeleisen in place of ferro-manganese.

In the review for 1914-1918 it was suggested that the great increase in the American manganese industry would not prove to be permanent, as it had taken place under the stimulus of restricted supplies and high prices. This, in fact, proved to be the case, and by 1922 the output of ore carrying 35 per cent. of manganese or over fell to 13,404 tons. During the quinquennium 1924-1928 however, the American production averaged 58,540 tons annually, with a peak production of 98,324 tons in 1925. This increased production was largely obtained from the State of Montana, partly in the form of carbonate ore and partly as oxide of chemical quality. Nearly all the manganese-ore won in the United States of America during the war was produced at a loss, which Congress decided to make good from the War Minerals Relief Department. To aid the American manganese industry, Congress in 1922 imposed special import duties on manganese-ore and ferro-manganese. The duty on manganese-ore was 1 cent. per pound of metallic manganese for ores containing over 30 per cent. manganese contents. This gives the heavy duty of \$11·12 per ton on 50 per cent. ore. A small portion of the increased production from 1923 to 1928 may be attributed to the effects of the tariff. The major portion is, however, due to the output of carbonate ores and chemical ores from Montana already referred to. These ores are of high enough grade to be produced even without the aid of the tariff.

In 1929 this import duty of 1 cent. per lb. was removed, only to be reimposed in 1930 not only on ore with 30 per cent. of manganese, but also on ores having down to 10 per cent. of metal. This was expected to stimulate the American production, and whilst the output of ore with 35 per cent. of manganese and over did rise to 67,035 tons in 1930, that of ore with 10 to 35 per cent. of manganese fell slightly, and with the slump of 1932 the output of American manganese-ore (35 per cent. and upwards) fell to 17,777 tons in 1932, to recover only to 18,558 tons in 1933. Agitation in favour of an embargo on the import of manganese-ore from Russia on the score of 'dumping' was unsuccessful.

As was anticipated in the review for 1914-1918, there was not, on the termination of the war, a parallel set-back to the Brazilian manganese industry, which has remained on a permanently increased scale until the present quinquennium and consequently a portion of the post-war imports of Brazilian ore into America has been at the expense of India. During the present quinquennium the Brazilian production has made an even steeper dive than that of India, falling from 288,685 tons in 1929 to 19,979 tons in 1932. The average annual exports of Indian ore to the United States of America before the war was 123,060 tons over a 10-year period: the average exports during the war quinquennium was 49,923 tons, whilst during the post-war quinquennium they recovered to 65,505 tons, and during the quinquennium 1923 to 1928 to 73,959 tons. During the quinquennium under review these exports have fallen from 51,500 tons in 1929-30 to 28,120 tons in 1931-32 with complete cessation in 1932-33 and 11 tons in 1933-34, the annual average for the period being only 25,696 tons. At one time it seemed likely that, with the growth of the American steel industry, India would again secure the same volume of exports to the United States; but with the appearance of new producers (Gold Coast and South Africa), as well as the Soviet methods of working manganese in Russia, this now seems less likely.

Although the Indian manganese industry was until recently in a position of comparative stability, it has, of course, been subject to variations in prosperity, as is illustrated graphically by the fluctuations in production recorded in fig. 5, page 36, the plunge of the last two years being the most serious and disastrous happening in the history of the industry. On comparing this diagram with the curves of the world's production of pig-iron and steel shown in figure 12[1], it is seen that the variations in the activity of the Indian manganese industry are to be correlated with variations in the activity of the iron and steel industry. In the previous review it was pointed out that the maxima of manganese-ore

[1] The crossing of the curves for pig-iron and steel in 1914 is not an error, but is due to the increasing quantity of steel scrap that is used in the manufacture of steel. The curves indicate that some decades were required for the accumulation in the world of a sufficient capital stock of steel for the wastage therefrom, when returned to the smelters, to produce the effect shown. The curves were due to cross in any case in 1914, but the war with its accompanying greatly increased wastage has accentuated the difference. The curves indicates also that the extra wastage of metals due to war is not as great as at first seems to be the case, owing to the ability of modern industry to utilise scrap metal.

production coincide with maxima of steel production, whilst the minima lag one year behind. This lag means, of course, over-production during years of lessened demand, with resultant accumulation of stocks. The rule was not, however, followed in 1919, for difficulty in securing sufficient ocean shipping caused the minimum of production of manganese-ore to precede, in 1918, the minimum of production of steel of 1919. The rule was, however, again complied with at the next minimum when the steel minimum occurred in 1921, and the Indian manganese minimum in 1922. In 1927, the Indian manganese maximum instead of coinciding with the steel maximum for the same year has been followed by an increased steel production in 1928, rising to a maximum in 1929, when there was a second but lower maximum of manganese-ore production in India. The world slump of 1932 was so serious that the minima of manganese-ore and steel production coincided.

The varying demands of the steel trade make their effect felt on the manganese industry in part through corresponding variations in the price of manganese-ore, and it is interesting therefore to compare the curves of the world's production of iron and steel forming the lower part of figure 12 with the curves showing the price of manganese-ore forming the upper part of the same figure. The two sets of curves have a tendency to move in close sympathy, but the very sharp rise in the curve of prices of manganese-ore since 1914, and the sudden fall in 1921-22, indicates the introduction of another factor into the problem besides the activity of the steel trade. This factor is, of course, the excessively high freights that prevailed during the war and for two years after on account of the shortage of shipping. The consequence is that the rapid rise in the curve of market price of manganese-ore cannot be taken as the measure of a corresponding increase in the profits accruing to the manganese industry of India. The sharp rise in 1923, coming to a peak in 1924, is, however, practically independent of freight charges. From 1924 onwards, the curves of market price of manganese-ore and production of steel have moved in opposite directions up till 1929, due to over-production of manganese-ore, relative even to the increased demand from the steel industry. Since then the two curves have fallen in sympathy to 1932.

In Table 61 is given a statement of the prices of first-grade manganese-ore *c.i.f.* United Kingdom ports during the quinquennium,

Prices. The quotations have been taken from the *Mining Magazine.* The mean prices shown in the third column have been obtained by averaging the quotations for the twelve months of each year. In figure 12 these prices are compared with the world's production of pig-iron and steel.[1]

As already noticed, the steep rise in the curve of prices during 1915 to 1918, and the sharp falls in 1919 and 1921, are largely due to enhanced freights during the war period and their subsequent fall: consequently, in order to discover the extent to which the Indian manganese industry may have benefited by the increased prices it is necessary to eliminate the portions representing freight and reduce to *f.o.b.* prices. This is desirable also, because, for the same reason, it was found necessary during the war to base the sliding scale of royalties applied in the Central Provinces and Bombay on *f.o.b.* prices instead of the *c.i.f.* prices formerly used. Table 62 gives the necessary data and reveals that although the price of manganese-ore during the war *c.i.f.* at United Kingdom ports increased by some 100 to 320 per cent., the effective increase to the manganese industry of India was only some 60 to 100 per cent.

Subsequent to the war, however, prices rose in 1920 to a still higher level than at any time during the war in spite of a considerable fall in ocean freights. The result was that exports of manganese-ore during 1920-21, amounted to more than double the tonnage exported during 1919-20, yielding a very substantial profit to the Indian manganese industry, in spite of the high rupee-sterling exchange rates prevailing in 1920.

During the quinquennium 1924-1928, freights fell to pre-war values, and, in consequence, as the *c.i.f.* prices of manganese-ore, though steadily falling, were even by 1928 still considerably in excess of the average pre-war values, the *f.o.b.* prices were also substantially in excess of pre-war figures, this excess being a measure of the profit then obtainable by the industry.

During the quinquennium now under review however, in spite of freights below pre-war figures, the fall in the price of manganese-ore per unit has been such as to reduce the *f.o.b.* value below that

[1] Strictly speaking the portion of the above curves representing the war period should give the world's production exclusive of those countries—Austria, Hungary, Belgium, Germany, and Russia—that were isolated from the world's markets. Such reduced figures give curves very similar to those actually shown, but faulted for the period 1914 to 1918 to a position about 20 million tons lower in the diagram.

TABLE 61.—*Variation in the price of first-grade Manganese-ore* c.i.f. *at United Kingdom ports.*

Date.	Price per unit in pence.	Mean price for year in pence.
January 1929	16	14·0
July 1929	14	
January 1930	13¾	13·1
July 1930	13½	
January 1931	12¾	11·7
July 1931	12	
January 1932	10—10½	9·5
July 1932	9—9½	
January 1933	9½	9·5
July 1933	9½	
January 1934	9½	10·5
July 1934	10½	
January 1935	11	..

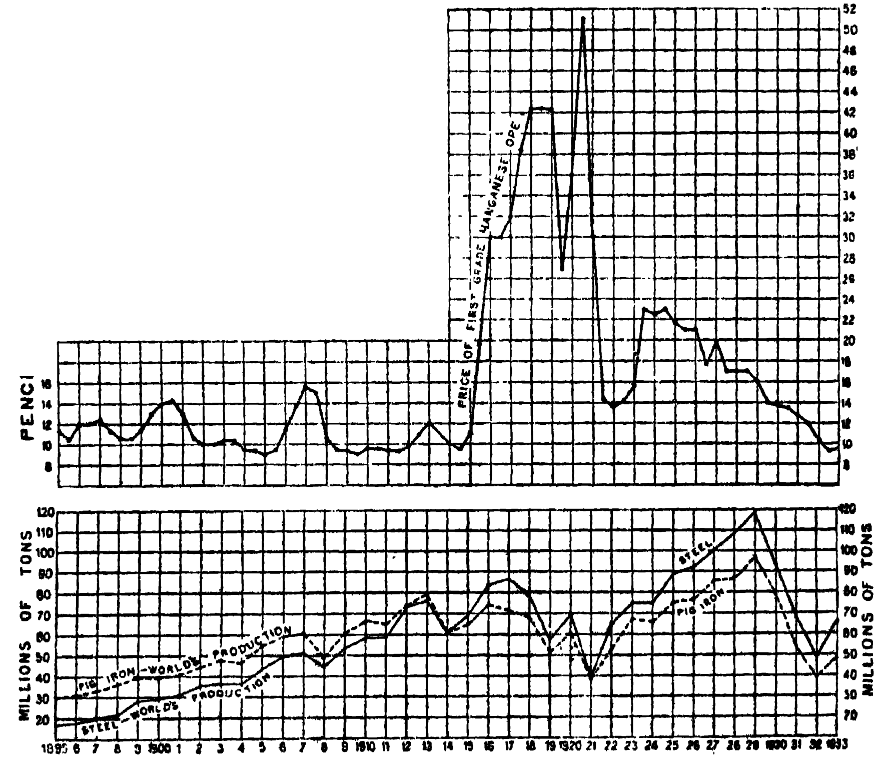

FIG. 12.—*Variation in the prices of Manganese-ore at United Kingdom ports since 1895, compared with the world's production of Pig-iron and Steel.*

TABLE 62.—*Comparison of ocean freights with* c.i.f. *and* f.o.b. *prices of Indian Manganese-ore.*

Year.	Average freights per ton from Calcutta and Bombay to U. K. ports.	Average price of 1st grade ore per unit *c.i.f.* U. K. ports.	Value per ton 50% ore *c.i.f.* U. K. ports.	Value per ton *f.o.b.* Indian ports.[1]	Corresponding price per unit *f.o.b.* Indian ports.
	£ *s. d.*	*Pence.*	£ *s. d.*	£ *s. d.*	*Pence.*
1914	0 17 9	10·17	2 2 4½	1 3 1½	5·75
1915	2 1 6	20·17	4 4 0½	2 0 0½	9·6
1916	4 1 8	30·7	6 7 11	2 3 9	10·5
1917	5 11 8	37·7	7 17 1	2 2 11	10·3
1918	6 3 0½	42·5	8 17 1	2 11 6½	12·37
1919	3 11 0	29·6	6 3 4	2 9 10	11·96
1920	4 9 4	45·5	9 9 7	4 17 9	23·46
1921 . . .	1 5 0	17·6	3 13 4	2 5 10	11·00
1922	0 19 2	13·9	2 17 11	1 16 3	8·70
1923	1 1 4	21·2	4 8 4	3 4 6	15·48
1924	1 2 8	22·9	4 15 5	3 10 3	16·86
1925	1 0 11	21·6	4 10 0	3 6 7	15·98
1926	1 0 3	18·4	3 16 8	2 13 11	12·94
1927	0 19 5	18·1	3 15 5	2 13 6	12·84
1928	0 17 5	17·0	3 10 10	2 10 11	12·22
1929	0 19 2	14·0	2 18 4	1 16 8	8·80
1930	0 18 0	13·1	2 14 7	1 14 1	8·18
1931	0 14 4	11·7	2 8 9	1 11 11	7·66
1932	0 15 3	9·5	1 19 7	1 1 10	5·24
1933	0 14 3	9·5	1 19 7	1 2 10	5·48

[1] Obtained by deducting from the *c.i.f.* values not only ocean freights, but also destination charges taken at 2*s.* 6*d.* per ton.

of 1914, and thereby, in view of the higher post-war railway freights and wages, to extinguish profits for the majority of producers.

During the period now under review the following limited liability companies were at work. Most of them were formed during the years 1905 to 1907; but the Vizianagram Mining Co. was floated in 1895.

Companies working.

Bombay—

1. The Shivrajpur Syndicate.

Central Provinces—

1. The Central India Mining Company: went into liquidation in 1929.
2. The Indian Manganese Company.
3. The Central Provinces Manganese Ore Company (name changed from Central Provinces Prospecting Syndicate in 1924).

Madras—

1. Vizianagram Mining Company.
2. The General Sandur Mining Company.

Mysore—

1. The United Steel Companies (formerly the Workington Iron and Steel Company): the New Mysore Manganese Department, Shimoga, went into liquidation in July 1932.
2. The Peninsular Minerals Co. of Mysore. (Ceased working from 1931).

Other prominent workers during this quinquennium have been :—

The Carnegie Steel Company: Central Provinces. Properties sold to the Central Provinces Manganese-ore Company in 1931.

The Tata Iron and Steel Company: Central Provinces.

Rai Bahadur Bansilal Abirchand Mining Syndicate: Central Provinces.

Bird and Company: Bihar and Orissa.

Production.

Table 63 shows the production from each district, state and province during the past five years, and figure 5 on page 36 shows the progress of the industry since its beginning. From this it will be seen that, neglecting

the effects of the slump in 1932 to 1933, the Central Provinces is by far the most important province as a producer of manganese. The figures in this table represent, except in a few cases, quantities of ore won or raised, and not of ore railed.

Comparing this quinquennium with the previous five years, it will be seen that the average annual production of manganese-ore for the whole of India shows a very large decrease from 953,039 to 558,596 tons. The previous quinquennium was, however, that of the greatest average annual production yet recorded, and in spite of the disastrous slump of 1932 and 1933 the average annual production of 1929 to 1933 is comparable with the figures for two earlier quinquennia, namely 509,144 tons for 1904 to 1908 and 577,457 tons for 1914 to 1918. Although the annual average for the period under review was thus not so unfavourable, yet this average is misleading, for the actual annual production fell from 994,279 tons in 1929 to 212,604 tons in 1932, with a trivial recovery to 218,307 tons in 1933. For such low totals it is necessary to go back to the infancy of the industry, the output for 1904 being 150,190 tons. The great decrease recorded during the quinquennium under review was not shared by all the provinces, for Bihar and Orissa showed an increase in the annual average of some 1,600 tons (2·8 per cent.) due to increases from Keonjhar State and Singhbhum and a small output from Bonai State, offset by a complete cessation of production from Gangpur State; whilst Madras showed an increase of some 15,000 tons (12 per cent.) annually due to a considerable increase from Sandur State with a trivial output from Cuddapah district, offset by a substantial decrease in the output of Vizagapatam and a decrease in the output of Bellary. Thus small increases in Bihar and Orissa and Madras were entirely overshadowed by the decrease in other provinces amounting annually in round figures to 344,000 tons (52 per cent.) in the Central Provinces, 41,000 tons (56 per cent.) in Bombay and 20,000 (62 per cent.) in Mysore. There was also a cessation of production in Jhabua State, Central India, which averaged 5,557 tons in the previous period. The decreases in Bombay, the Central Provinces and Mysore were shared by all producing districts except North Kanara, which showed a trifling increase due to production in 1929 and 1930. The most disastrous falls in output were those of the Balaghat and Nagpur districts of the Central Provinces, amounting annually to 154,000 and 138,000 tons respectively.

TABLE 63.—*Production of Manganese-ore in India*

—	Bihar and Orissa.			
	Bonai.	Keonjhar.	Singhbhum.	Total.
	Tons.	Tons.	Tons.	Tons.
1929 . . .	..	53,433	22,698	76,131
1930 . . .	165	37,356	11,203	48,724
1931 . . .	..	39,665	7,938	47,603
1932 . . .	..	44,908	2,272	47,180
1933 . . .	3,115	60,407	7,453	70,975
TOTAL .	3,280	235,769	51,564	290,613
Provincial average.	..	..	..	*58,123*
Provincial average 1924-28.	..	..	..	56,524

—	Central Provinces.					Madras.		
	Balaghat.	Bhandara.	Chhindwara.	Nagpur.	Total.	Bellary.	Cuddapah	Kurnool.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons
1929 . . .	263,105	156,525	29,814	172,559	622,003	10,535	..	..
1930 . . .	220,018	150,133	27,170	155,023	552,344	3,470	50	..
1931 . .	119,466	82,999	16,404	83,475	302,344	44	..	..
1932 . . .	36,762	10,918	10,041	19,465	77,186	..	..	..
1933 . . .	20,501	60	8,228	..	28,789	..	..	300
TOTAL .	659,852	400,635	91,657	430,522	1,582,666	14,049	50	300
Provincial average.	..	..	..	..	*316,533*	..	..	..
Provincial average 1924-28	..	..	..	..	600,559	..	..	..

during the five years 1929 to 1933.

Bombay.				Total.
Belgaum.	Chhota Udepur.	North Kanara.	Panch Mahals.	
Tons.	Tons.	Tons.	Tons.	Tons.
8,666	9,415	6,245	56,326	80,652
2,856	3,984	4,500	36,542	47,882
474	..	..	31,184	31,658
..	..	612	..	612
..	..	..	..	..
11,496	13,399	11,357	124,052	160,304
..	..	..	..	*32,061*
..	..	..	..	73,440

Madras.			Mysore.				Total for the whole of India.	
Sandur.	Vizagapatam.	Total.	Chitaldrug.	Shimoga.	Tumkur.	Total.		
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Statute Tons.	*Metric Tons.*
140,604	24,533	175,672	667	38,436	718	39,821	994,279	*1,010,187*
145,961	13,213	162,694	241	18,283	278	18,802	829,946	*843,225*
149,833	5,389	155,266	425	548	..	973	537,844	*546,450*
79,023	8,049	87,072	219	335	..	554	212,604	*216,006*
101,260	16,698	118,258	5	280	..	285	218,307	*221,800*
616,681	67,882	698,962	1,557	57,882	996	60,435	2,792,980	*2,837,668*
...	..	*139,792*	..	..	..	*12,087*	558,596	*567,534*
..	..	124,918	..	..	..	32,046	(a) 953,039	968,288

(a) Including an average production of 5,557 tons in Central India.

TABLE 64.—*World's annual production of*

(Statute

Year.	Austria-Hungary. (a)	Brazil.	China. (b)	Cuba.	Dutch East Indies.	Egypt.	France.	Gold Coast.	India.
1913 .	39,609	(b) 120,335	..	11,406	..	..	7,608	..	815,047
1914 .	28,870	(b) 180,679	..	9,716	..	..	6,290	..	682,898
1915 .	33,513	(b) 284,032	..	9,000	..	..	10,158	..	450,416
1916 .	22,310	(b) 495,044	..	33,120	..	..	10,633	(b) 4,258	645,204
1917 .	136,884	(b) 524,291	..	44,406	..	..	11,403	(b) 31,136	590,813
1918 .	177	(b) 387,066	20	81,966	..	27,064	9,712	(b) 30,292	517,953
1919 .	5,182	(b) 202,419	2,997	(b) 31,212	2,868	47,965	6,903	(b) 35,189	537,995
1920 .	37,161	(b) 446,445	24,923	(b) 22,163	4,112	73,316	10,200	(b) 40,970	736,439
1921 .	56,866	(b) 271,263	25,223	(b) 622	2,059	54,180	1,892	(b) 7,195	679,286
1922 .	43,907	(b) 335,230	18,926	(b) 9,059	2,278	102,469	689	(b) 66,113	474,401
1923 .	70,086	(b) 232,041	27,234	19,320	5,159	130,256	5,897	(b)139,634	695,055
1924 .	98,382	(b) 156,670	37,928	24,903	8,346	147,780	4,920	(b)255,343	803,006
1925 .	106,653	321,336	42,577	23,376	(b) 9,866	79,316	3,939	(b)357,165	839,461
1926 .	127,562	256,420	41,789	(b) 24,256	11,765	119,943	4,520	398,551	1,014,928
1927 .	158,040	238,004	45,617	(b)127,704	14,727	150,431	5,502	(b)369,205	1,129,353
1928 .	161,240	314,774	42,648	(b) 85,698	24,066	135,330	3,965	(b)324,490	978,449
1929 .	156,608	288,685	62,200	(b) 8,400	20,065	188,453	2,560	(b)419,224	994,279
1930 .	94,335	159,478	70,700	977	16,426	119,297	2,018	(b)417,490	829,946
1931 .	86,087	142,731	24,000	6,491	14,311	100,174	325	(b)247,191	537,844
1932 .	34,580	19,979	21,500	2,113	8,156	322	..	50,689	212,604
1933 .	521	(u) 25,000	(u)20,000	89,224	10,298	184	..	265,140	218,307

(a) Figures for 1913 to 1915 include Bosnia and Herzegovina: for 1916 Bosnia and Herzegovina only: for 1917 exclude Austria: for 1918, 1919, are for Austria only: for 1920, for Austria and Czecho-Slovakia: for 1921, 1922, 1923, 1924, are for Austria, Czecho-Slovakia and Jugoslavia: for 1925, 1926, 1927, 1928, 1929 for Austria, Czecho-Slovakia, Jugoslavia and Hungary: for 1930, 1931, 1932 for Czecho-Slovakia, Jugoslavia and Hungary: for 1933 Jugoslavia only.

(b) Exports.

(c) Georgia only.

(d) Years ended 30th September.

(e) Includes Panama, 10,498 tons.

(f) Includes Costa Rica, 7,163 tons and Argentina, 6,600 tons.

(g) Includes Costa Rica, 9,630 tons and Australia, 8,891 tons.

(h) Includes Germany, 10,800 tons and Costa Rica, 7,726 tons.

(j) Includes Chile, 11,446 tons.

Manganese-ore during the years 1913 to 1933.

Tons.)

Italy.	Japan.	Rumania.	Russia and Georgia.	Spain.	Sweden.	United Kingdom.	United States.	Other Countries.	World's Total.	*Percentage of total produced in India.*
1,596	17,755	..	1,234,900	21,247	3,937	5,393	4,048	1,322	2,284,203	35·7
1,622	16,803	..	891,400	12,944	3,584	3,437	2,635	601	1,841,479	*37·1*
12,375	25,470	..	528,900	14,098	7,485	4,640	9,613	3,779	1,393,479	*32·3*
17,855	48,547	..	(c) 247,000	13,950	8,751	5,140	31,474	(e) 29,764	1,613,050	*40·0*
24,138	50,579	..	(c) 201,380	56,550	19,554	9,042	129,405	(f) 32,978	1,863,549	*31·7*
31,383	56,109	..	(c) 150,000	70,465	16,304	17,456	305,869	(g) 43,862	1,751,698	*29·6*
30,345	22,523	5,694	56,200	65,614	12,081	12,078	55,322	(h) 31,331	1,163,918	*46·2*
35,577	5,389	3,315	95,403	20,914	14,686	12,875	94,420	(j) 40,321	1,718,689	*42·8*
5,025	3,821	2,986	(c) 28,364	19,775	6,145	514	13,531	20,748	1,199,490	*56·6*
4,619	4,371	5,305	(c) 192,651	25,046	4,438	250	13,404	8,204	1,311,360	*36·2*
9,451	5,406	12,810	(c) 237,014	28,175	4,964	2,021	31,500	(k) 24,911	1,680,434	*41·4*
11,902	7,463	6,378	(d) 420,084	20,505	10,706	2,457	56,515	(l) 36,066	2,109,354	*38·1*
14,747	11,850	5,288	(d) 665,620	35,502	10,768	829	98,324	(m)30,835	2,657,447	*31·6*
13,789	14,969	8,221	(d) 1,012,362	44,237	15,017	128	46,258	(n) 29,667	3,184,382	*31·9*
9,601	27,125	10,205	(d) 830,228	36,288	16,557	1,509	44,741	(o) 29,068	3,243,905	*34·8*
10,112	17,413	30,773	(d) 661,801	13,488	15,541	235	46,860	(p) 72,445	2,939,337	*33·3*
9,760	18,100	34,485	(d) 1,236,939	17,590	14,378	..	60,379	(q) 65,638	3,598,343	*27·6*
10,465	..	32,998	1,543,862	16,553	8,542	..	67,085	(r)196,228	3,585,847	*23·1*
6,820	2,871	18,490	862,000	17,633	8,232	..	39,242	(s)126,902	2,240,844	*24·0*
872	5,333	4,971	813,000	2,550	4,653	..	17,777	20,280	1,218,879	*17·4*
4,453	(u)5,000	2,387	982,000	3,720	6,122	..	18,558	(t) 95,000	1,745,000	*12·5*

(k) Includes Germany, 10,080 tons.
(l) Includes Portugal, 6,564 tons.
(m) Includes Chile, 10,887 tons.
(n) Includes Chile, 10,473 tons, and Greece, 6,248 tons.
(o) Includes Greece, 7,955 tons and Chile, 7,567 tons.
* (p) Includes Unfederated Malay States 48,851 tons and Chile 9,046 tons.
(q) Includes Unfederated Malay States 32,183 tons, Morocco 12,942 tons, and Chile 8,055 tons.
(r) Includes Union of South Africa 144,994 tons, Unfederated Malay States 20,696 tons, Morocco 15,907 tons and Chile 6,040 tons.
(s) Includes Union of South Africa 100,290 tons and Morocco 10,659 tons.
(t) Includes Union of South Africa 20,894 tons.
(u) Estimated.

Production of foreign countries.

The activity of the Indian manganese industry during the past 20 years, and its importance as compared with that of other countries can be seen from Table 64, giving the world's production of manganese-ore for the years 1913 to 1933. The figures have been taken chiefly from the reports of the Imperial Institute and are given in long tons.

From this table it will be seen that for many years the three leading countries producing manganese-ore were Brazil, India, and Russia. During the pre-war quinquennium, the output, or rather exports, of Brazil sank from a maximum of 249,941 long tons in 1910, to 120,335 tons in 1913, the average annual exports being 186,172 tons. During the same period, the production of India fluctuated between about 650,000 and 830,000 tons, averaging 712,797 long tons, whilst that of Russia rose almost continuously from 565,856 long tons in 1909, to 1,234,900 tons in 1913, with an annual average of 740,906 tons.

During the war quinquennium, the output, or rather exports, of Brazil rose from a minimum of 180,679 tons in 1914, to 524,291 tons in 1917, the average annual exports being 374,222 tons. During the same period, the production of India fluctuated between about 450,000 and 680,000 tons, averaging 577,457 tons, whilst that of Russia, including Georgia, fell continuously from 1,234,900 tons in 1913, and 891,400 tons in 1914, to 150,000 tons in 1918, with an annual average for 1914-1918 of 404,000 tons. During the same period, the production of the United States of America rose from 2,635 tons in 1914, to 305,869 tons in 1918, with an annual average of 95,799 tons. In fact, as is shown graphically in Plate 6, the war led ultimately to an almost complete cessation of the Russian manganese industry, to a moderate contraction of that of India, and to a resultant great expansion in the production of manganese-ore in Brazil and the United States of America; so that in 1918, the first three places amongst the world's producers were held by India, Brazil, and the United States of America, in the order named. During the war quinquennium, largely increased outputs were forthcoming from some of the other small producers, of which Cuba, Italy, Japan, Spain and Sweden may be mentioned. In addition a multitude of new producers appeared on the scene of which the Gold Coast and Egypt (Sinai) alone need be mentioned.

During the succeeding quinquennium (1919-1923), the Indian production recovered to an average of 624,635 tons, the Brazilian exports fell somewhat to an average of 297,479 tons, whilst the Russian exports averaged some 170,000 tons, probably largely from stocks. During the same quinquennium, the output of the United States of America reverted nearly to the pre-war level, as did that of many other countries, but the production of Egypt rose to 130,256 tons in 1923, and that of the Gold Coast to 139,634 tons in the same year, these two countries then ranking as the fifth and fourth producers respectively. China also became a small regular producer.

In the quinquennium 1924-1929 the Indian production rose to an average of 953,039 tons, a figure some 50 per cent. higher than the quinquennial average of 1909-1913; the Brazilian average fell still further to 263,675 tons, while the Russian (including Georgian) production rose to 730,279 tons, a figure still below the average for the pre-war quinquennium 1909-1913 (740,906 tons); the average annual production of the Gold Coast rose to 352,232 tons, making it the fourth largest producer of manganese-ore, whilst the production of Egypt, the fifth largest producer, averaged 126,560 tons.

In the quinquennium under review the world's output fell from a total of 3,598,343 tons in 1929, the highest ever recorded, to 1,218,879 tons in 1932, the lowest recorded for many years except for the two post-war years of 1919 and 1921. There was a recovery to some 1,745,000 tons in 1933. As would be expected, this fall to 1932 was shared by all important producers though to different extents, whilst many countries shared small or large recoveries in 1933, the most striking being of the Gold Coast (exports) from 50,689 tons in 1932 to 265,140 tons in 1933, and of Cuba from 2,113 tons in 1932 to 89,224 tons in 1933. The Indian average production fell during the quinquennium by 41·4 per cent. to 558,596 tons; the Brazilian average fell by 50 per cent. to 127,175 tons; but the Russian (including Georgia) production in spite of a fall during the quinquennium showed an average production of 1,087,460 tons, which is 49 per cent. in excess of the average for the previous quinquennium, and only some 131,000 tons below the world's total production for 1932: this high average was of course helped by the high production of 1930, namely 1,543,362 tons. During this

same period the average annual production of the Gold Coast fell to 279,947 tons, making it the third most important producer of manganese-ore, whilst that of Egypt, the fifth largest producer, fell to an average of 81,686 tons, the output of 1932 and 1933 being trivial. During this period South Africa became a producer with an initial output of 9,202 tons in 1929 jumping to 144,994 tons in 1930, followed by a complete stoppage in the slump of 1932, with resumption of work in 1933, the annual average for the quinquennium being 55,076 tons.

The totals shown under Austria-Hungary in Table 64 include the output of Austria, Czecho-Slovakia, Hungary, and Jugo Slavia, of which that of Czecho-Slovakia is important, 95,004 tons in 1929, falling to 32,951 in 1932. The Egyptian deposits are in Sinai, only 10 to 15 miles from the port of Abu Zenima, and the total reserves are estimated at 11,848,000 tons, averaging 32·3 per cent. manganese and 25 per cent. iron, the ore being a ferruginous manganese-ore. The ore from the Gold Coast is in part first-grade manganese-ore showing 51 to 52 per cent. manganese, and, as such, it enters into competition with the Indian ore.

Another country that is likely to become a serious competitor with India is South Africa, where large deposits of first-grade manganese-ore have been discovered near Postmasburg in Griqualand West, a portion of the Cape Province. The deposits occur in two ranges—the Gamagara and Klipfontein ranges—and in the western or Gamagara range they have been followed almost continuously for 30 miles, and there is no doubt that the tonnages of ore available are enormous. The ore is hard and compact like that of the Central Provinces of India, and chemically much of it is said to be of first-grade quality. It is intended to select the ore to give a product averaging 52 per cent. manganese, 6 per cent. iron, 5 per cent. silica and phosphorus up to 0·1 per cent. To connect Postmasburg with the existing railway system of South Africa, 65 miles of railway have been constructed, and the ore is railed to Durban for shipment.

It seems clear from the data of the past quinquennium that the expansion of the Russian manganese-ore industry must be looked upon as a permanent factor. In addition to exports, much Russian ore (from Nikopol) is now used in connection with the growing Russian iron and steel industry. The electric furnace

production of ferro-manganese in Georgia is also said to have commenced (in 1933).[1] The Russian ore needs washing before shipment and is in many cases too small and soft to be used without admixture with harder lump ores of the Central Provinces (or South African) type, so that there appears to be a limit to the extent to which the Russian ore can secure the available markets. Nevertheless, the great Russian production with its accessibility to the sea-board and cheap methods of production is a commanding factor in reducing or destroying the prosperity of other producers of manganese-ore.

In the previous quinquennial review an attempt was made to discuss the future price of manganese-ore per unit. It was shown that the pre-war lower governing price of manganese-ore was 9*d.*, this being the lowest figure at which the majority of the world's manganese mines could work at a profit. And it was calculated that in 1929 with an index figure of cost of supplies and services of 145 (1913 being 100) the post-war governing price of manganese-ore should be 13*d.*, and that the price was already approaching the new minimum, having reached 14*d.* Meanwhile the cost of living index figure has continued to fall, so that it reached 91 in 1932 and 87 for 1933. The corresponding minimum prices for manganese-ore based on 9*d.* as the pre-war minimum are 8·2*d.* for 1932 and 7·8*d.* for 1933.[2] These may be compared with 9·5*d.*, the mean price for each of these two years for first-grade Indian manganese-ore *c.i.f.* at United Kingdom ports, with washed Caucasian ore nearly ½*d.* to 1*d.* cheaper. Approximately, therefore, Indian manganese-ore should have been marketable at a profit during these years. Actually the index figure is now misleading, as it does not allow for wages and freights, which have not fallen *pari passu* with the cost of commodities.

With the appearance at intervals of new producers, it is of interest to trace the extent to which India has maintained her position. During the pre-war quinquennium, India produced 40·8 per cent. of the world's average total annual production of some 1,750,000 tons of manganese-ore; during the war quinquennium, the Indian

[1] 'Mineral Industry for 1933', p. 395.

[2] *Indian Trade Journal*, 26th December, 1929, p. 762, and 14th February, 1935, p. 842. Index numbers of wholesale prices in Calcutta by groups of articles: wages and freights not included.

proportion fell to 34·1 per cent. out of an average total annual production of some 1,690,000 tons, whilst, during the post-war quinquennium, the Indian proportion rose to 43·2 per cent. of the reduced world's output of some 1,445,000 tons annually. During the quinquennium 1924-1928, whilst the Indian production rose to a figure never previously attained, the Indian proportion fell to 33·5 per cent. on account of the increase in the world's total annual output to nearly 2,840,000 tons. In the quinquennium now under review the Indian proportion fell very seriously to 22·5 per cent. of a reduced annual world's total output of some 2,478,000 tons.

Production of manganiferous iron-ores.

In earlier reviews a table was given of the world's production of manganiferous iron-ores. Data, however, became so scanty that it was found necessary to give figures for the United States only (*see* Table 65). This manganiferous iron-ore shows a startling decrease during 1931 to 1933 corresponding with the slump in the American iron and steel industry. Formerly, all manganiferous ores containing less than 40 per cent. manganese were included, but, since 1918, the line between manganese-ores and manganiferous iron-ores has been drawn at 35 per cent. manganese[1]. The importance of large stores of manganiferous iron-ores to a country poor in manganese-ores proper is shown by the case of the United States, where an insufficiency of imports of manganese-ore during the war was mitigated by a large expansion in the output of indigenous manganiferous iron-ores accompanied by modifications in furnace practice where necessary. In the case of Germany, also, the cessation of imports of manganese-ore from Russia and India was met to a large extent by a greatly increased production of the manganiferous iron-ores of Siegerland,[2] and it is unfortunate, therefore, that the relevant figures are not available for inclusion in the above table. In addition to the United States of America, there is a small production of manganiferous iron-ore in Spain, Algeria, Greece and Italy; further, by the United States of America standards the Egyptian ore (*see* Table 64) would be classified as manganiferous iron-ore, as also would a very small proportion of the Indian ore.

[1] See p. 221 for a scheme of classification of manganese-ores.
[2] H. C. H. Carpenter, *Nature*, 4-11-15, p. 257.

TABLE 65.—*United States production of Manganiferous Iron-ore from 1929 to 1933.*

(Statute Tons.)

Year.	Ores containing from 10 to 35 per cent. Mn.	Ores containing from 5 to 10 per cent. Mn.	Total.
1929	78,191	1,110,067	**1,188,258**
1930	77,417	707,973	**785,390**
1931	64,062	217,352	**281,414**
1932	15,635	9,799	**25,434**
1933	12,779	178,852	**191,631**

For comparison with the annual figures of production of manganese-ore in India, the export figures during the years 1929 to 1933 are given in Table 66 (stated separately for each port). As compared with those for the previous quinquennium these figures show a great falling off during 1931 to 1933 in the exports from Bombay and Calcutta. The exports from Marmagao, however, remained remarkably steady considering the slump, whilst Vizagapatam in 1933 commenced its career as a modern port.

Exports.

TABLE 66.—*Exports of Indian Manganese-ore from 1929 to 1933.*

(Statute Tons.)

Year.	Vizagapatam.	Bombay.	Calcutta.	Marmagao.(*a*)	Total.
1929 . .	13,980	325,268	440,302	184,939	**964,489**
1930 . .	4,500	297,738	300,211	170,577	**773,026**
1931 . .	4,331	88,681	153,535	171,410	**417,957**
1932 . .	3,200	58,145	131,399	108,508	**301,252**
1933 . .	61,940	51,747	146,121	116,546	**376,354**

(*a*) Figures exclude ore raised in Goa.

From Table 67, giving the total Indian production and exports for the years 1892 to 1933, it will be seen that by the end

of 1933, there was an excess of production over exports of 1,609,918 tons, of which, however, 608,121 tons is accounted for by railings to Tatanagar, Kulti, and Burnpur, from 1911 to date after allowing for ore sold by the Tata Iron and Steel Co. for export; the remainder (1,001,797 tons) represents stocks accumulated at the mines and ports and is smaller by about 118,000 tons than the surplus recorded in the previous review after allowing for ore railed to the ironworks. This decrease in stocks is due to the production during the quinquennium being less than the sum of the exports *plus* internal consumption. This is a reversal of the trend of the previous quinquennium when continuous over-production prevailed.

TABLE 67.—*Comparison of Indian Manganese-ore production with exports.*

(Statute Tons.)

Period.	Ore produced.	Ore exported.	Excess of production over exports.
1892 to 1903	929,145	..	..
1892-93 to 1903-04	..	916,386	12,759
1904 to 1908	2,545,718	..	..
1904-05 to 1908-09	..	2,217,596	328,122
1909 to 1913	3,563,984	..	..
1909-10 to 1913-14	..	3,471,416	92,568
1914 to 1918	2,887,284	..	..
1914-15 to 1918-19	..	2,457,790	429,494
1919 to 1923	3,123,176	..	..
1919-20 to 1923-24	..	3,409,862	—286,686
1924 to 1928	4,765,197	..	..
1924-25 to 1928-29	..	3,795,522	969,675
1929 to 1933	2,792,980	..	..
1929-30 to 1933-34	..	2,728,994	63,986
Total	20,607,484	18,997,566	1,609,918

TABLE 68.—*Distribution of exported Indian Manganese-ore for the years 1929-30 to 1933-34* (a).

(Statute Tons.)

Year.	Belgium.	Canada.	France.	Germany.	Italy.	Japan.	Netherlands.	Norway.	Sweden.	United Kingdom.	United States of America.	Other Countries.	Total recorded export for the year.
1929-30	177,584	..	208,238	22,550	4,246	15,290	34,350	2,300	300	292,377	51,500	6,938	815,673
1930-31	78,495	3,260	188,409	15,330	620	5,799	11,500	5,000	2,500	114,010	48,850	12,000	485,773
1931-32	35,400	100	80,325	1,820	..	6,129	2,500	3,500	..	53,843	28,120	..	211,737
1932-33	32,452	1,000	74,591	1,311	400	30,599	2,000	..	..	55,377	..	..	197,730
1933-34	18,854	400	60,954	2,920	..	62,000	3,060	1,000	..	116,902	11	..	266,101
TOTALS (1929-30 to 1933-34)	342,785	4,760	612,517	43,931	5,266	119,817	53,410	11,800	2,800	632,509	128,481	18,938	1,977,014
TOTALS (1924-25 to 1928-29)	908,627	5,000	833,754	77,934	47,432	24,042	39,311	479	1,000	808,732	369,796	8,429	3,124,536
TOTALS (1919-20 to 1923-24)	948,974	..	531,728	27,017	61,622	9,558	75,850	..	2,800	1,224,288	327,529	1,254	3,210,620
TOTALS (1914-15 to 1918-19)	72,603	..	233,721	14,250	61,025	62,536	..	..	..	1,680,796	239,616	4,231	2,368,778
TOTALS (1909-10 to 1913-14)	749,859	..	484,596	33,402	14,400	19,289	93,275	..	..	966,111	660,988	13,610	3,035,530

(a) Excludes exports *viâ* Marmagao.

The distribution amongst foreign countries of the manganese-ores exported from India during the quinquennium is shown in Table 68. The figures for the war quinquennium, as compared with the similar data for the pre-war quinquennium, showed certain abnormal features. The first feature was the disappearance of Belgium, Germany, Holland, and Austria-Hungary from the importing countries for the period of the war: the second was the large decrease in the exports to France and the United States: and the third the large increase in the exports to the United Kingdom—1,680,796 tons in the war quinquennium as compared with 966,111 tons during the previous period.

Distribution of Indian manganese-ore exports.

During the post-war quinquennium (1919-20 to 1923-24) the data showed a partial reversion to the pre-war figures, which was maintained during the next quinquennium (1924-28 to 1928-29), except for France, which showed an abnormal increase in imports to 833,754 tons, as compared with her pre-war figure of 484,596 tons. The total imports of Germany, Holland and Belgium (most of which are for consumption in Germany) were 1,025,872 tons against 876,536 tons in the pre-war period. The imports of the United States of America fell to 369,796 tons against 660,988 tons for the pre-war period, whilst those of the United Kingdom fell to 808,732 tons against 966,111 tons for the pre-war period. The net balance was a total of exports from India of 3,124,536 tons during the quinquennium 1924-25 to 1928-29 against 3,035,530 tons during the pre-war quinquennium. During the quinquennium under review the total Indian exports fell heavily to 1,977,014 tons, and the fall was shared by most of the important countries. Thus the total exports to Belgium fell from 908,627 tons in the previous quinquennium to 342,785 tons; of France from 833,754 tons to 612,517 tons; of the United Kingdom from 808,732 tons to 632,509 tons and of the United States of America from 369,796 tons in 1924-25 to 1928-29 to 128,481 tons in 1929-30 to 1933-34. On the other hand there was a substantial increase in exports to Japan from 24,042 tons in 1924-25 to 1928-29 to 119,817 tons in the present quinquennium, whilst there were smaller increases to the Netherlands, Norway and Sweden.

In Vizagapatam and Mysore an adequate supply of labour seems to be easily obtainable, but in the Central Provinces, the Sandur

Hills, and other parts, labour has frequently to be imported.

Labour.

To relieve themselves of unnecessary trouble and responsibility the mine managers find it preferable to work through contractors, paying them at a given rate per 1,000 cubic feet of stacked and cleaned ore, and for dead-work at a given rate per 1,000 cubic feet of cavity made in the quarry in the case of soft 'deads', or per 1,000 cubic feet of waste measured in tubs or stacked in the case of hard 'deads'. On account of the slump in the industry and the fall in the price of food-stuffs, the daily rates paid to the coolies by the contractors for an eight hours' day have fallen considerably and now vary between the following limits in different parts of India[1] :—

	Annas.
Men	4 to 6
Women and children (over thirteen)	2 to 3

But in the Central Provinces most coolies work on piece-work rates, and if they work reasonably well can earn sums in excess of the above figures.

The average daily number of workers during the past five years is shown in Table 69, the average annual figure being less than half that of the previous quinquennium, the figure for 1933, namely 4,545 workers, being the smallest recorded since 1904, for which the total was 4,515.

In order to permit of the comparison of the manganese with the coal industry as regards labour, the figures appertaining only to those mines that come under the revised Mines Act, 1923, are given in Table 70. From these figures it is seen that the average number of persons employed daily on the manganese mines under the Act has been 12,611 for an average annual output of 372,664 tons compared with 28,779 persons and an average annual output of 766,185 tons of ore for the previous quinquennial period. The number of tons of ore won annually per person employed has decreased steadily from 39·4 tons during the pre-war quinquennium to 36·6 tons during the war quinquennium and 35·0 tons during the quinquennial period 1919-1923. There was apparently a very heavy fall during the previous period, when the output was only 26·6 tons per person employed; since when there has been a slight rise to 27·6 tons during the present period. The decrease during three

[1] The lower rates refer to cultivators in Madras who combine mining with agriculture.

earlier periods was due to the depletion of the supplies of easily-won ore, so that an increasing amount of dead work became necessary every year: but the large decrease during the period 1924-29 was mainly due to the fact that under the revised Mines Act of 1924, all the small inefficiently worked quarries, which were previously excluded, are now included. In the quinquennium now under review there was a slight rise to 27·6 tons. The output of coal per person employed was more than four times the above figure. The death rate was 0·25 per 1,000 persons employed, as compared with 1·06 in the case of coal: these figures are lower than for the period 1924-1928, when the corresponding figures were 0·37 and 1·16 respectively. At the same time the number of deaths per million tons won has increased in the case of manganese from 6 in 1914-1918, to 11·3 in 1919-1923, and 13·8 in 1924-1928, falling to 8·7 in 1929-1933; and in the case of coal has varied from 10·7 to 13·9 and 10·1, and to 8·6 in 1929-1933.

TABLE 69.—*Daily number of workers employed at the Manganese Mines from 1929 to 1933.*

Year.	Bihar and Orissa.	Bombay.	Central Provinces.	Madras.	Mysore.	TOTAL.
1929	3,137	4,339	20,404	3,447	644	31,971
1930	1,774	2,096	13,515	3,326	382	21,093
1931	1,587	1,327	9,508	2,167	50	14,639
1932	1,380	159	2,971	1,184	42	5,736
1933	1,773	64	1,136	1,549	23	4,545
Average	*1,930*	*1,597*	*9,507*	*2,335*	*228*	*15,597*

TABLE 70.—*Labour statistics for Manganese Mines under the revised Mines Act, 1923.*

Year.	Average number of persons employed daily.	Production. (in tons)	Output per person. (in tons)	Number of deaths.
1929	27,243	750,908	27·6	6
1930	17,658	623,678	35 3	8
1931	11,982	347,373	29·0	..
1932	3,896	88,119	22·6	2
1933	2,274	53,240	23·4	..
TOTAL	63,053	1,863,318	..	16
Average	*12,611*	*372,664*	*27·6*	*3·2*

Cost of mining and transport.

The chief items in the cost of placing manganese-ore on the markets in Europe and America are the following :—

(1) Cost of mining (labour, tools, plant, establishment).
(2) Cost of transport to the railway.
(3) Cost of transport to the port of shipment.
(4) Cost of handling at the port of shipment.
(5) Cost of shipping to Europe or America.
(6) Destination charges.

Each of these six items—the first five of which vary according to the situation of the deposit—has been considered in detail in *Memoirs, Geol. Sur. Ind.*, XXXVII, Chapter XXIII, to which the reader is referred. In an earlier review an abstract was given showing the average cost of delivering *c.i.f.* at English and Continental ports manganese-ore derived from several of the producing areas. These figures were in the main based on information collected prior to 1910, and with the changes of prices and conditions since the war have ceased to be applicable. Revised figures for all the areas concerned have not been obtained, but it will be sufficient to give as an example the following revised figures for the Central Provinces, the most important producing province :—

—	*Viâ* Bombay.			*Viâ* Calcutta.		
	Limits.		Average.	Limits.		Average.
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Cost of mining (labour, tools, plant and administration).	6 8 0	14 12 0	7 3 0	..	..	6 10 0
Transport to rail-head . .	0 3 0	6 0 0	0 8 0	..	..	0 9 0
Railway freight . . .	10 14 0	14 13 0	12 8 0	12 0 8	12 11 0	12 2 0
Handling at port . . .	2 8 0	2 10 6	2 10 0	..	..	1 14 6
Agents' commission and administration.	0 2 9	1 2 0	0 6 0	0 2 9	1 0 0	0 4 6
	..	..	23 3 0	..	..	21 8 0

These figures are applicable to the period 1929 to 1933, and on comparing them with the figures given in the memoir referred to above and in the previous reviews, it will be seen that the average cost of delivering ore from the Central Provinces *f.o.b.* Bombay increased from about Rs. 14 per ton in the pre-war quinquennial

period and about Rs. 17 during the war quinquennium to about Rs. 24 (£1=Rs. 15) during the post-war quinquennium and to about Rs. 24 (£1=Rs. 13·3) during the quinquennium 1924-1928, and fell slightly to Rs. 23 (£1=Rs. 13·3) during the quinquennium under review. These increases against pre-war figures are due to increases under every item in the total, except that the building of feeder railways has in many cases reduced the second item; in effect, taking an exchange value for the rupee of 1*s*. 6*d*., it will be seen that the cost of delivering manganese-ore *f.o.b.* Bombay has increased by about 80 per cent., as compared with pre-war costs with exchange at 1*s*. 4*d*. The slight fall in the quinquennium under review is due to minor adjustments, and with mining costs slowly rising with increasing depth it is clear that a substantial reduction of total costs can be obtained only by reduction of railway freights. A comparison of the figures given in Table 62 with the average price of first-grade manganese-ore per unit during the pre-war quinquennium *f.o.b.* Indian ports (6·18*d*.) will show that the increased market price of manganese-ore met adequately the increased cost of production up to the end of the previous quinquennium. It was then remarked that a fall in *c.i.f.* prices from 17·0*d*., the average figure for 1928, to 13*d*. would, however, extinguish the profit based on costs of production of Rs. 24 per ton *f.o.b.* During the quinquennium under review such a fall has taken place, the *c.i.f.* price falling during 1932 to 9·5*d*., with a corresponding *f.o.b.* price of 5·24*d*. equivalent to Rs. 14·55 per ton. As the cost of production fell only to Rs. 23 per ton *f.o.b.* the result was the almost complete cessation of work in 1932.

Royalties. In British India the royalty leviable on the base metals is—

'2½ per cent. on the sale value at the pit's mouth, or on the surface, of the dressed ore or metal, convertible at the option of the Local Government to an equivalent charge per ton to be fixed annually for a term.'

On account of the inconvenience and labour involved in assessing rates of royalty separately for each manganese-ore deposit and producer, it has for some years been customary in each area to assume average figures for the composition of the ore and for the costs of mining, transport, etc., and to apply them without distinction to all cases. The first sliding scale drawn up on these assumptions was framed by the Central Provinces administration and was based on *c.i.f.* values at United Kingdom ports: during the war period

the high ocean freights upset the schedule and it was replaced by the following sliding scale based on *f.o.b.* values Bombay :—

TABLE 71.—*Royalties, in annas per ton, leviable on Manganese-ore extracted in the Central Provinces and Bombay.*

F.o.b. price per unit of first-grade ore.	Royalty leviable per ton of ore.
Pence.	*Annas.*
$5\frac{1}{2}$	$\frac{1}{2}$
6	$1\frac{1}{5}$
$6\frac{1}{2}$	$1\frac{4}{5}$
7	$2\frac{4}{5}$
$7\frac{1}{2}$	3
8	$3\frac{3}{5}$
$8\frac{1}{2}$	$4\frac{1}{5}$
9	$4\frac{4}{5}$
$9\frac{1}{2}$	$5\frac{2}{5}$
10	6

The wide fluctuations in the rupee-sterling exchange during the post-war period rendered this schedule also inapplicable : it would have been easy to rectify this difficulty by basing royalties on the *f.o.b.* price stated in annas instead of pence, but on account of the possibility of variation of other factors, the Local Government decided, in 1921, to abandon sliding scales altogether and to revert to the system of assessing royalty at $2\frac{1}{2}$ per cent. on the sale value of the ore at the pit's mouth. This necessitates detailed returns by each producer based on the actual facts of each year, and forms suitable for the purpose have been drawn up. The royalties charged according to this method are shown in Table 72. The actual rates of royalty charged according to the sliding scale during the quinquennium in the Central Provinces for concessionaires who have not accepted the revised system in respect of concessions granted prior to the 6th June 1921, are shown in Table 73. Bombay has adopted the same method of assessment.

TABLE 72.—*Average royalties in annas per ton charged on Manganese-ore in the Central Provinces during each half year for the years 1929 to 1933 on concessions granted after the 6th June, 1921.*

	January to June.	July to December.
	Annas.	*Annas.*
1929	5·16	5·25
1930	5·75	4·67
1931	3·75	2·41
1932	1·83	2·58
1933	2·33	2·33

TABLE 73.—*Royalties actually levied in the Central Provinces during the years 1929 to 1933, on the sliding scale based on prices.*

Year.	ROYALTIES LEVIED.		Average *f.o.b.* price for year.
	January to June.	July to December.	
	Annas.	*Annas.*	*Pence.*
1929	6·0	4·8	8·8
1930	4·2	3	8·2
1931	2·4	2·4	7·7
1932	1·8	2·4	5·2
1933	3·6	3·6	5·5

In Bihar and Orissa royalty is levied at 2½ per cent. on pit's mouth value, subject (in a few cases only) to a minimum royalty of two or three annas a ton.

In the Indian States a fixed royalty irrespective of price is usually arranged when a prospecting license or mining lease is granted. The rates prevailing in certain States are as follows :—

TABLE 74.—*Royalty, in annas per ton, levied in certain Indian States and Zamindari lands.*

State.	*Royalty.*
Jhabua State, Central India	4 annas.
Mysore State	From 1st April 1928, 10 annas per ton on all grades of ore subject to revision after 2 years (*a*).
Sandur State, Madras	6 annas.
The Vizianagram Samasthanum, Madras	4 „

(*a*) From 1920, to October, 1924, the royalty was Re. 1-4 per ton for ores containing more than 44 per cent. of manganese, and otherwise annas 12 per ton. From October, 1924, licensees were, in addition, required to pay to Government not less than 25 per cent. of the net profits. In March, 1926, the royalty on low grade ore was raised to annas 6 per ton. The United Steel Companies, Ltd., were granted a special concession rate of royalty of annas 6 per ton upon low grade ore of 30 per cent. manganese and under for two years from 20th August, 1930 for a stipulated quantity of 75,000 tons.

Valuation of manganese-ore.

From Table 61 and the diagram (fig. 12) on page 196, it will be seen that the price per unit of manganese, and consequently the price per ton of manganese-ore obtained on its delivery *c.i.f.* at the port of destination, is subject to great variations. Up till November, 1909 (*Mining Journal*), the following classification was in use :—

1st grade	50 per cent. Mn. and upwards.
2nd „	47—50 per cent. Mn.
3rd „	40—47 per cent. Mn.

But from December, 1909, the following schedule was employed :—

1st grade	50 per cent. Mn.
2nd „	48—50 per cent. Mn.
3rd „	45—48 per cent. Mn.

and during the war, quotations have been given for first-grade ore only. Since the war, also, quotations have been practically confined to first-grade ore, but of late quotations for second-grade ore have appeared at intervals, and have been usually about one or two pence below first-grade prices. The lower limit for first-grade ore has fallen to 48 per cent. Mn.

As an example of the way in which the schedule of prices was applied we can take the case of a 50 per cent. ore from the Central Provinces in December, 1914. The average price at this time was 11 pence per unit. The price then paid per ton for this ore would be 50×11 pence=£2-5-10.

The prices given in Table 61 apply to ore delivered in the United Kingdom, and for this scale to be applicable it was formerly necessary that the ore should not contain more than 10 per cent. of silica and 0·10 per cent. of phosphorus.

Before the war, a schedule of prices was fixed periodically by the Carnegie Steel Company and one such schedule is quoted in a previous Quinquennial Review. The great rise in prices during the war period led to the announcement in 1918, by the War Industries Board, of a revised schedule fixing the price per unit of manganese for each 1 per cent. rising from 35 per cent. upwards. This schedule also no longer applies, and manganese-ores are now quoted *c.i.f.* docks at prices per unit roughly equivalent to the sterling price per unit *c.i.f.* U. K. ports. The import duty is additional and amounts to 1 cent. per pound of metallic manganese in ores and concentrates containing over 30 per cent. of manganese.

Valuation for chemical purposes.

The prices noticed above are those relating to manganese-ores intended for use in the iron and steel industry. For ores suited for use in the chemical industries as oxidising agents much higher prices are often obtained. For chemical purposes it is not the percentage of manganese that is of importance, but the percentage of oxygen liberated on treating the ore with acid, *i.e.*, the *available oxygen.* This is usually expressed in terms of the percentage of manganese peroxide, MnO_2. Not only does the percentage of MnO_2 affect the price, but also the ease with which the ogygen is liberated. Further, impurities that are soluble in acid, and so cause an unnecessary consumption of it, are deleterious. The best minerals for chemical purposes are pyrolusite, psilomelane, and hollandite. For the glass industry the ore must be as free as possible from iron. The only Indian pyrolusite yet found sufficiently pure for the glass industry is that of Pali in the Nagpur district. A picked specimen of this giving 95·57 per cent. MnO_2 showed only 0·06 per cent. Fe_2O_3. High-grade pyrolusite suitable for batteries is now worked in Keonjhar State, and averages 85 per cent. MnO_2 and 0·45 per cent. of iron.

Nomenclature of manganese-ores and manganiferous iron-ores.

It is customary to divide the ores of iron and manganese into iron-ores, manganiferous iron-ores, and manganese-ores. The least percentage of manganese in an iron-ore that is usually paid for is said to be 5 per cent. and with less than 5 per cent. of manganese it hardly seems necessary to prefix the adjective 'manganiferous'. The dividing line between manganiferous iron-ores and manganese-ores was formerly taken at 44 per cent. manganese (=70 per cent. MnO_2). Later, ores with as little as 40 per cent. manganese have been termed manganese-ores, and those below this limit manganiferous iron-ores.[1] According to this method one often sees an ore referred to as manganiferous iron-ore that contains much more manganese than iron. Such a difficulty can easily be avoided by creating a class for *ferruginous manganese-ores*. Accordingly, in *Memoirs, Geol. Surv. Ind.*, XXXVII, page 500, (1909), the following classification was proposed. It is applicable to all ores containing over 50 per cent. of Mn+Fe. The term *ferruginous manganese-ores* is now coming into general use.

——	Mn. per cent.	Fe. per cent.
Manganese-ores	40—63	0—10
Ferruginous manganese-ores . .	25—50	10—30
Manganiferous iron-ores . . .	5—30	30—65
Iron-ores	0—5	45—70

Analyses of manganese-ores.

On pages 501 to 509 of the work cited above a series of tables of analyses of Indian ores will be found. A good idea of the quality of the ores obtained in different parts of India can be gleaned from the range and mean values of these analyses as summarised in the Tables 71 and 72 of the review for the period 1914-18. The second of

[1] In the United States in 1918, the limiting percentage was lowered to 35, and the following classification is now used :—

Manganese-ores	35 per cent. and over.
Ferruginous manganese-ores . . .	10 to 35 per cent.
Manganiferous iron-ores	5 to 10 per cent.

The middle sub-division includes ores that would be better termed manganiferous iron-ores.

TABLE 75.—*Mean of analyses of Manganese-ores and Manganiferous Iron-ores from the different districts and provinces of India.*

PROVINCE	BIHAR AND ORISSA.				BOMBAY.				CENTRAL INDIA.	CENTRAL PROVINCES.	
DISTRICT	GANGPUR.		SINGHBHUM.		BELGAUM.		PANCH MAHALS.	SATARA.	JHABUA.	BALAGHAT.	BHANDARA.
Class of ore.	Higher grade.	Lower grade.	Manganese-ore.	Manganiferous iron-ore.	Ferruginous manganese-ore.	Manganiferous iron-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.
Number of analyses.	Half the limits.	Half the limits.	3	3	10	2	4	4	5	13	13
	Per cont.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Manganese	49·5	45	47·66	11·84	44·77	10·53	41·68	40·79	46·94	51·88	51·94
Iron	7	7·5	2·90	34·93	10·33	49·55	4·07	6·94	8·44	7·40	7·27
Silica	6	8	4·63	16·46	1·40	2·27	19·11	3·75	8·14	3·74	4·59
Phosphorus	0·18	0·13	0·34	0·74	0·035	0·023	0·20	0·07	0·20	0·11	0·14
Moisture	..	..	0·63	1·17	..	..	0·35	1·99	0·43	0·37	0·44
Manganese + Iron	56·5	52·5	50·56	46·77	55·10	60·08	45·75	47·73	55·38	59·28	59·21

TABLE 75 (*contd.*).—*Mean of analyses of Manganese-ores and Manganiferous Iron-ores from the different districts and provinces of India.*

PROVINCE.	CENTRAL PROVINCES—*contd.*					MADRAS.				MYSORE.		
										SHIMOGA.		
DISTRICT.	CHHINDWARA.	NAGPUR.	JUBBULPORE.			SANDUR.	VIZAGAPATAM.			New Mysore Manganese Company.		Shimoga Manganese Company.
								Supplied by Vizianagram Mining Company.		Ferruginous manganese-ore.		
Class of ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganiferous iron-ore.	Iron-ore.	Ferruginous manganese-ore.	Ferruginous manganese-ore.	Manganese-ore.	Ferruginous manganese-ore.	Higher grade.	Lower grade.	Manganese ore.
Number of analyses.	8	30	3	7	4	6	12	8	7	3	Half the limits.	9
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Manganese	52·72	51·53	45·56	20·26	0·96	47·75	42·96	44·34	46·75	46·75	37	49·10
Iron	7·08	6·24 ([illegible])	4·79	28·78	50·50	11·45	11·22	9·08	15·20	10·06	15	7·74
Silica	7·16	7·25	2·68	12·99	10·76	0·61	4·29	4·15	5·72([illegible])	1·77	4	2·62
Phosphorus	0·14	0·11	0·215	0·25	0·32	0·030	0·27	0·32	0·335	0·031	0·035	66·85
Moisture	0·38	0·49 ([illegible])	0·56	..	0·336	..	0·90	..	..	0·95	1	..
Manganese + Iron	59·80	57·77	50·35	49·04	51·4	59·20	54·18	53·42	51·95	56·81	52	6·84

TABLE 76.—*Composition of Indian Manganese-ores as exported.*

PROVINCE.	BIHAR AND ORISSA.			BOMBAY.					CENTRAL PROVINCES.	
PRODUCER.	BIRD & CO.			SHIVRAJPUR SYNDICATE (a).					CENTRAL PROVINCES MANGANESE-ORE COMPANY (c).	
District or State.	*Keonjhar* (a).			*Chhota Udepur* (b).	*Panch Mahals.* Shivrajpur.			*Bamankua* (b).	*Balaghat, Bhandara and Nagpur.*	
Class of ore.	1st grade.	2nd grade.	Peroxide.	1st grade.	1st grade.	2nd grade.	Low grade.	1st grade.	1st grade.	2nd grade.
Tonnage represented	34,298	1,20.498	4,151	10,344	79,666	9,379	18.762	9,265	885,069	129,072
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Manganese	48·0 —50·1	38—42	54·4 —58·85	48·1	50·6	46·6	43·4	49·5	48·29—55·63	44·98—48·83
Iron	7—6	14	1·7 — 0·45	4·12	4·62	4·00	3·45	3·9	4·69— 8·70	5·73—12·43
Silica	6—3	4	4·3 — 0·78	4·50	4·80	10·27	15·40	6·5	3·25—11·74	3·68—13·77
Phosphorus	0·15—0·075	0·09	0·09— ..	0·155	0·215	0·208	0·195	0·235	0·050—0·184	0·075—0·224
Manganese + Iron	55—56	52—56	56·1—59·30	52·44	55·22	50·60	46·85	53·4	54·77—59·82	52·46—59·16
Peroxide of manganese	..	..	81·2—88·2	..	..	..	..	..	..	..

(a) Analysis of ore despatched. (b) Lower grade ores also produced. (c) Analysis of ore produced.

TABLE 76 (*contd.*).—*Composition of Indian Manganese-ores as exported.*

PROVINCE.	CENTRAL PROVINCES—*contd.*			MADRAS.				MYSORE.
PRODUCER.	CENTRAL PROVINCES MANGANESE-ORE COMPANY (*a*)—*contd.*	INDIAN MANGANESE COMPANY (*b*).		GENERAL SANDUR MINING COMPANY.	VIZIANAGRAM MINING COMPANY.			UNITED STEEL COMPANIES.
District or State.	*Bhandara* (Dongri Buzurg).	*Chhindwara.*	*Nagpur.*	*Sandur* (*b*).	*Vizagapatam.*			*Shimoga* (*c*).
Class of ore.	Peroxide.	1st grade.	1st grade.	Ferruginous manganese-ore.	Manganese-ore.	Ferruginous manganese-ore.	Peroxide.	Ferruginous manganese-ore.
Tonnage represented . .	3,351	73,885	61,399	616,681	38,604	28,381	897	..
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Manganese	52·36—57·95	51·82—52·98	48·22—49·36	39·8—40·95	44·1—45·2	35·0—39·6	..	36—38
Iron	1·25— 5·14	5·04— 5·40	6·68— 7·52	(*d*)	(*d*)	11·7—16·5	0·9—4·8	10·6—11·6
Silica	0·59— 2·59	8·73— 9·87	8·88— 9·87	(*d*)	(*d*)	(*d*)	..	9·4—10·6
Phosphorus . . .	0·232—0·385	0·110—0·157	0·2—0·231	(*d*)	(*d*)	(*d*)	..	0·023—0·026
Manganese + Iron . .	57·50—59·20	56·97—58·38	55·74—56·59	..	..	49·2—53·2	..	..
Peroxide of manganese . .	83·90—88·10	..	..	..	..	..	76·1—91·6	..

(*a*) Analysis of ore produced.
(*b*) Analysis of ore shipped. Tonnages are of ore produced.
(*c*) Figures for previous quinquennium. Later figures not available.
(*d*) Not available.

these only is now repeated (Table 75), but in addition another (Table 76) is added representing the composition of the manganese-ores worked in India during the quinquennial period under review and based on figures for which I am indebted to the various mining companies. Certain differences between the figures in these two tables merit comment. In the case of the Panch Mahals, the figures given in Table 75 relate to outcrop samples taken before the deposits were opened up and without any selection, such as would naturally take place when the ores were worked; the average quality of ore as exported is of much higher grade. The ores from the Central Provinces worked during the present period show a slight decrease in manganese contents, a slight increase in silica contents, and a slight increase of phosphorus contents, compared with the analyses summarised in Table 75, which relate chiefly to samples taken by myself in 1903-04. The ores from Sandur State as exported show roughly the same total manganese and iron contents, as in the earlier figures, but the iron contents are markedly higher at the expense of the manganese contents.

Analyses of cargoes of Indian and foreign ores landed at Middlesborough.

In order to show the value of the Indian ores relative to those of certain foreign countries two tables (73 and 74) were given in the review for 1914-1918 showing the limits and averages, respectively, of a large number of cargoes of manganese-ores and manganiferous iron-ores landed during the years 1897-1906 at Middlesborough. In later reviews only the table of average values has been repeated. It seems unnecessary to continue to reproduce these figures, but it may be mentioned that they represented not only Indian manganese-ores, but also the manganese-ores of the Caucasus, Brazil and Chile, and the manganiferous iron-ores of Greece and Spain (*viâ* Carthagena). The figures show that the Indian ores contain less moisture than those of the other countries. Some of the latter contain such large quantities of moisture—Caucasus, 8·67 per cent.; Brazil, 11·35 per cent.; and Spain, 8·44 per cent.—that it is necessary to reduce the analyses to their condition when dried at 100° C. before any fair comparison can be made. From the figures representing the dried ores it will be seen by reference to previous reviews that the Indian ores stand first as regards manganese contents, with Brazil a close second; as regards silica, Brazil stands first, with India second; as regards phosphorus, however, India stands last but one, the only ores containing more phosphorus being those of Russia;

the Indian ores contain much less iron than the manganiferous iron-ores of other countries; but of the true manganese-ores they contain the highest amounts of iron, in spite of the fact that they also contain the highest amounts of manganese. The high iron contents of the Indian ores may be regarded as a point in their favour, or otherwise, according to the use to which the ores are to be applied. It is true that the high iron contents make it more difficult to manufacture the very highest grades of ferro-manganese from the Indian ores; but, on the other hand, if the very highest grades are not required, then the iron is of considerable value. Both manganese and iron are of use in this case, and the buyer obtains the following totals of Mn+Fe when he buys the ores of the different countries:—

	Mn.+Fe. Per cent.
India	57·17
Brazil	54·09
Russia	50·41
Chile	48·40
Greece	47·99
Sp	44·27

With the figures in Table 77 may be compared the analyses of the average ore from the Gold Coast [1]:—

	Per cent.
Manganese	50—53
Iron .	2—4
Silica ..	3—7
Phosphorus	0·1—0·12

Value of the Indian manganese-ore production.

The valuation of the Indian manganese-ore production is a question of some interest. There are of course several ways of stating the value. Manganese-ore possesses one value per ton as stacked at the pit's mouth, another as delivered *f.o.r.* at the rail-head, a third as delivered *f.o.b.* the ship at the port of shipment, a fourth as delivered *c.i.f.* at the port of destination, and a fifth after it has been converted into ferro-manganese. For example, with the price at 9½ pence per unit, the average value of 50 per cent. Central Provinces ore, with 1933 data for freight charges, etc., exported *viâ* Bombay may be taken as:—

Rs.	AS.	
0	0	at the pit's mouth.
2	12	*f.o.r.*
15	4	*f.o.b.*
26	7	*c.i.f.*

[1] Sir A. E. Kitson, *Gold Coast Geol. Surv.*, Bull. No. 1, p. 15, 1925).

TABLE 77.—*Means of analyses* of cargoes of Manganese-ores and Manganiferous Iron-ores landed at Middlesboroug hduring the ten years 1897 to 1906.*

COUNTRY.	INDIA.		(CAUCASUS).		BRAZIL.		CHILE.		GREECE.			SPAIN (*viâ* CARTHAGENA).	
Class of ore	Manganese-ore.		Manganese-ore.		Manganese-ore.		Manganese-ore.		Manganiferous iron-ores. *Raw.*		Manganiferous iron-ores. *Calcined.*	Manganiferous iron-ores.	
Number of cargoes.	26		77		25		9		54		18	24	
Period.	1900—1906		1898—1906		1898—1906		1898—1903		1897—1906		1897—1903	1897—1905	
Method of reporting analysis.	As received.	Dried at 100°C.	As received.	Dried at 100°C.	As received.	Dried at 100°C.	As received.	Dried at 100°C.	As received.	Dried at 100°C.	Dried at 100°C.	As received.	Dried at 100°C.
Manganese	50·49	50·86	45 28	49·58	44·60	50·314	47·51	47·99	16·15	16·96	43·01	19·35	21·13
Iron	6·26	6·31	0·76	0·83	3·35	3 78	0·41	0·41	29 54	31·03	41·32	21·19	23·14
Silica	5·67	5·71	9·29	10·17	1·81	2·04	7·26	7 33	7·27	7·33	7·33	11·18	12·21
Phosphorus	0·126	0·127	0·147	0·161	0·040	0·052	0·015	0·011	0·022	0·023	0·023	0·013	0·014
Moisture	0·72	..	8·67	..	11·35	..	1·01	..	4·79	..	..	8·44	..
Alumina, siliceous matter, etc. .	0·75	6·80	11·66	12·77	2·73	3·08	12·52	12·65	8·04	8·44	8·35	12·63	13·79

On these data the pit's mouth value is actually a *minus* value, which explains the depression of the industry in 1932 and 1933. The question of values is discussed at length in *Memoirs, Geol. Surv. Ind.*, Vol. XXXVII, Chapter XXV, and it is there shown that to obtain a true idea of the value of the industry to India the export or *f.o.b.* values must be considered. But it is also pointed out that the true value of the ore in the world's markets is the *c.i.f.* value. The export values formerly given were obviously much too low; they were based on figures supplied by the mine operators, and represented, apparently, the cost of winning the ore and placing it on board a ship at the port, and not the true value of the ore, which is the *c.i.f.* value *minus* charges incurred from the port of shipment to the port of destination. In the work already cited the export values have been re-calculated from the beginning of the industry. First the *c.i.f.* values per ton have been calculated separately for each area, on the basis of the average market price per unit of manganese-ore during the year, and an assumed average composition of the ores. From these *c.i.f.* values the *f.o.b.* values are obtained by deducting freights *plus* destination charges from the *c.i.f.* value per ton. The *f.o.b.* value per ton is then multiplied by the actual production for the year. The figures thus calculated for the years 1929 to 1933 are given in Table 78.

TABLE 78.—*Export value* f.o.b. *at Indian ports of the Manganese-ore produced in India during the years 1929 to 1 33.*

Year.	Bihar and Orissa.	Bombay.	Central Provinces.	Madras.	Mysore.	Total.	Value per Ton.
	£	£	£	£	£	£	£
1929 . .	101,303	138,179	1,140,338	154,703	36,507	1,571,030	1·580
1930 . .	56,566	73,431	929,778	125,265	15,196	1,200,236	1·446
1931 . .	53,357	49,334	501,387	122,073	803	726,954	1·352
1932 . .	25,596	620	84,261	29,345	200	140,022	0·659
1933 . .	44,047	..	32,868	46,138	118	123,171	0·564
TOTAL .	**280,869**	**261,564**	**2,688,632**	**477,524**	**52,824**	**3,761,413**	..
Average .	*56,174*	*52,313*	*537,726*	*95,505*	*10,565*	*752,283*	*1·120*

There is, however, in many years a considerable difference between the amounts of ore won and the amounts exported; during the quinquennium 1919-1923, in two years, namely 1919 and 1921, the amounts of ore won exceeded greatly the amounts of ore exported, whereas in the remaining three years the reverse relation held, the disparity being greatest in 1922. In the quinquennium 1924 to 1928 the amounts of ore won in each year exceeded the amounts exported. In the present quinquennium also, except in 1933, the amounts of ore won exceeded the amounts exported. The totals obtained as above differ, therefore, considerably from the total values actually obtained by the mining community. As figures for the amounts of ore exported are not obtainable in detail province by province the totals may be adjusted for these years by valuing the exports for the calendar years ending 31st December at the average value per ton derived from the total production. Treated in this way the total values for 1929 to 1933 become—

	£
1929	1,523,893
1930	1,117,796
1931	565,078
1932	198,525
1933	212,264

and these figures have been used in the table of total values (Table 1, page 11).

Comparing the export values of the manganese-ore production with the values for the other chief Indian mineral products given in Table 1 it will be seen that manganese now occupies the sixth place.

Manufacture of ferro-manganese in India.

In earlier reviews reference was made to the potential loss that India suffers through exporting her manganese-ore in the raw condition, instead of converting at least a portion of it into ferro-manganese in the country. It was satisfactory, therefore, to be able to record in an earlier review that during the war quinquennium the manufacture of ferro-manganese had been inaugurated in India. On account of the great increase in the price due to the war, one of the blast furnaces at Sakchi (now Jamshedpur) was diverted to the manufacture of ferro-manganese in October, 1915, the average output from one furnace being about 80 tons a day. In 1917, the manufacture of ferro-manganese at Sakchi was discontinued on account of the necessity of keeping both blast furnaces on the

production of pig-iron required for the manufacture of steel. The average composition of the ferro-manganese produced was :—

	Per cent.
Manganese	70
Phosphorus	0·55—0·66
Silicon	2—3

From November, 1917, one of the smaller blast furnaces of the Bengal Iron Company at Kulti was engaged in the production of ferro-manganese with a guaranteed minimum of 74 per cent. manganese and maximum of 0·55 per cent. phosphorus. The average monthly output was given as 1,150 tons, and the balance left over after satisfying the requirements of Sakchi, was exported, the total exports (to France, United States, Italy, and Natal) up to the end of August, 1918, being 7,555 tons. With the cessation of the war the production of ferro-manganese was discontinued at Kulti and resumed at Sakchi. The production of ferro-manganese in India during the present quinquennium is shown in Table 79.

TABLE 79.—*Production of Ferro-Manganese in India during the years 1929 to 1933.*

Year	Quantity.
	Tons.
1929	3,630
1930	4,576
1931	14,366
1932	366
1933	7,725
TOTAL	30,663
1924-1928	34,306

The ore used at Sakchi was in part railed from the Company's mines in the Central Provinces, the average composition of the ore railed during 1917 being as follows :—

	Per cent.
Manganese	50·41
Iron	6·38
Silica	4·36
Phosphorus	0·041

As will be seen from the figures given above the phosphorus contents of the alloy produced at Sakchi and Kulti were considerably higher than the figure 0·30 per cent. representing the upper limit of phosphorus acceptable abroad in normal times. With a careful selection of Indian ores (*e.g.*, of the composition of that already smelted at Sakchi, or ore from Balaghat running 0·07 per cent. phosphorus) and the use of Giridih coke running only 0·022 per cent. phosphorus, ferro-manganese could be produced with phosphorus within the acceptable figure. But considering that the amount of Giridih coke is limited, that Indian cokes are normally high in phosphorus, and that the percentage of phosphorus in the high-grade manganese-ores of the Central Provinces tends slowly to increase with depth from the surface, it is evident that India can never be a large producer of low-phosphorus ferro-manganese by blast-furnace methods. The possibilities of the electric production of such low-phosphorus alloy deserve, therefore, careful consideration. (Tatanagar is the station for Sakchi, now Jamshedpur.)

The fact that ferro-manganese is now being made in India renders it important to secure statistics of the amounts of manganese-ore railed to Tatanagar and Kulti and consumed in India, in order to enable one to deduce what portion of the difference between the figures of production of manganese-ore in India and exports thereof represents accumulated stocks. These data are collected in Table 80, from which it will be seen that the total quantity of ore railed to Tatanagar, Kulti, and Burnpur, up to 31st December, 1928, is 686,731 tons, of which 593,575 tons have been consumed, and 78,611 tons resold, leaving stocks of ore at the works amounting to 14,545 tons. It must be mentioned that manganese-ore is used not only in the manufacture of, ferro-manganese, but is also added to the blast

TABLE 80.—*Statistics of Manganese-ore received and consumed at the iron and steel works of India.*

(Statute Tons.)

	Tata Iron and Steel Co., Sakchi, Jamshedpur or Tatanagar.			Bengal Iron Co., Kulti.			Indian Iron and Steel Co., Burnpur.		
	Ore received.	Ore consumed.	Ore sold.	Ore received.	Ore consumed.	Ore sold.	Ore received.	Ore consumed.	Ore sold.
1913 (up to and including)	9,901	8,561	..	615	..	..	..	..	..
1914	6,792	7,804	..	1,122	..	..	..	..	..
1915	21,066	12,485	60	1,254	..	..	..	..	..
1916	5,646	8,137	1	1,389	..	..	..	..	..
1917	*nil*	6,356	..	10,326	..	..	..	..	..
1918	31,839	5,748	..	31,746	..	..	..	..	..
1919	81,737	8,637	..	4,748	..	..	..	..	..
1920	19,049	5,414	..	4,580	..	..	..	..	..
1921	*nil*	15,885	..	1,138	..	..	..	..	..
1922	20,799	8,864	..	5,070	..	..	307	81	..
1923	*nil*	16,175	36,061	3,558	..	..	2,229	2,144	..
1924	16,863	25,660	29,192	4,420	..	..	6,050	5,260	..
1925	21,044	20,943	10,268	2,264	..	..	14,934	11,636	..
1926	25,039	20,581	3,029	..	..	..	13,226	9,985	..
1927	25,027	19,733	..	5,043	..	..	18,915	14,869	..
1928	25,129	26,765	..	25,505	..	..	27,919	19,852	..
1929	25,030	19,811	..	6,036	..	..	22,423	20,688	..
1930	24,885	19,841	..	4,445	..	..	14,348	21,743	..
1931	18,000	41,694	..	..	..	..	316	11,343	..
1932	29,263	10,892	..	..	..	..	6,968	8,375	..
1933	28,604	27,396	..	..	..	..	10,124	11,693	..
TOTAL	**435,713**	**346,382**	**78,611**	**113,259**	**109,524**	..	**137,759**	**137,669**	..

Total ore received	686,731
Total ore consumed	593,575
Total ore sold	78,611
Total ore stocks December 31st, 1933	14,545

furnace charge in the manufacture of pig-iron, and in the open-hearth furnaces.

Other economic considerations.

The thoroughness with which India was prospected for deposits of manganese-ores during the first eight years or so of this century is shown by the fact that, during the quinquennial period 1909-1913, no fresh fields of importance were discovered, nor were any new deposits of importance located in areas already under exploitation; whilst during the succeeding period one fresh deposit only was opened up, namely Pani in Chhota Udepur, Bombay Presidency, the initial production of which dates from 1914, and which has yielded 186,082 tons of ore up to the end of the present quinquennium. During the period 1919-1923, manganese-ores were discovered in the iron-ore tracts of Keonjhar State in Orissa, and there was a small initial production in 1923, increasing to 194,469 tons during the following quinquennium and to 235,769 tons during the present quinquennium. Further during the present quinquennium there has been a small output from the iron-ore tracts of Bonai State. Work was also commenced (1926) on the lateritoid deposits of North Kanara.

As before, work has been continued almost everywhere on open-cast lines, but underground mining has been in progress for some years at Kandri in the Nagpur district, and at the Balaghat mine.[1] Gariajhor in Gangpur, where some underground work was done, has now been abandoned owing to water troubles.

With regard to the effects on output of the steadily increasing depth of the Indian manganese quarries, as would be expected, deposits of superficial origin, such as those of Vizagapatam, are, with the passage of years, giving a markedly decreased yield. But deposits of the gonditic type (chiefly in the Central Provinces) show no evidence of deterioration in depth, except when structural factors intervene, and except, also, for the very slight decrease in manganese contents and slight rise in silica and phosphorus contents that characterise many of these deposits, which features may, as noted in a previous review, be regarded as evidence of a certain amount of surface modification of these ores, originally consolidated in depth. The difficulties of these companies are economic rather than technical, and one of the pioneer companies, the Central India Mining

[1] B. V. Mellon, *Trans. Min. Geol. Inst. Ind.*, Vol. XXIV, pp. 165-174, (1929).

Company, has gone into liquidation and surrendered its lease due partly to the increased costs of working with increased depth. There are still, however, large quantities of ore to be won from the principal deposits, so that the principal company in the Central Provinces has not yet been impelled to test, by boring, the continuity of its deposits in depth.

In the review for 1914-1919, the abandonment was recorded of an important deposit of the gonditic type, namely Kajlidongri in the Jhabua State. During the quinquennium 1924-1928, work was resumed at this locality, but on a much smaller scale than previously, and during this quinquennium work has again been abandoned.

During the present period the economic conditions were so adverse that the majority of the small producers in the Central Provinces produced little or no ore. Whether this is the effect of economic conditions only is not at present known and will not be known until prosperous times return to the industry.

The year 1919 saw the abandonment (except for surface boulder accumulations) of a second valuable gonditic deposit, namely Sitapar in the Chhindwara district. This deposit was worked from a large open quarry, until at about 100 feet from the surface the ore-body was truncated by felspathic intrusives. The circumstances render it possible that the remainder of the ore-body may lie concealed underground in one or more fragments. From the commencement of work in 1906, until the end of 1921, the Sitapar deposit yielded 70,600 tons of ore of exceptionally high grade, and in addition no less than three minerals new to science (*see* also page 240).

As several of the ores of manganese are distinctly magnetic, though usually only slightly so, it seems desirable to determine the possibilities of magnetometric surveying in locating the position of underground bodies of manganese-ore. The prospects of success in such application of these methods do not seem very bright; but this much has been ascertained, that a dipping-needle set up directly on a manganese-ore deposit is often strongly affected thereby.

Geological Relations of Indian Manganese-ores.

In view of the importance of the Indian manganese industry it is proposed to repeat below, with such slight alterations as are necessary, the brief sketch of the distribution and mode of occurrence of

the Indian deposits given in the previous review[1]. The deposits of economic value can be divided into three main groups—

(*A*) Deposits associated with rocks of Dharwar age—the manganiferous facies of which is known, when containing spessartite-garnet, as the *gondite* series. Found in—

Bihar and Orissa :—*Gangpur*.
Bombay :—Narukot, *Panch Mahals*, *Chhota Udepur*.
Central India :—*Jhabua*.
Central Provinces :—*Balaghat*, *Bhandara*, *Chhindwara*, *Nagpur* and Seoni.

(*B*) Deposits associated with a series of manganiferous intrusives known as the *kodurite* series. Found in—

Madras :—Ganjam, *Vizagapatam*.

(*C*) Deposits occurring as *lateritoid* replacement masses on the outcrops of Dharwar rocks. Found in—

Bihar and Orissa :—*Keonjhar*, *Singhbhum*.
Bombay :—Dharwar, *North Kanara*, Ratnagiri.
Central Provinces :—*Jubbulpore*.
Goa.
Madras :—*Bellary*, *Sandur*.
Mysore :—*Chitaldrug*, *Kadur*, *Shimoga*, *Tumkur*.

(Italics denote that ore has been worked for export.)

In addition to the occurrences noted above, ore has been worked in the low-level laterite of Goa and the high-level laterite of Belgaum (though this occurrence—Talevadi—might perhaps be more accurately classed with the lateritoid occurrences). Manganese-ores have also been found in many other districts in India, but none of these other occurrences has been shown to be of any value. Amongst them, the following may be mentioned :—

In Bijawar rocks :—Dhar, Gwalior, Indore, Hoshangabad.
In Vindhyan rocks :—Bhopal.
In Kamthi rocks :—Yeotmal.
In Lameta rocks :—Dhar, Indore, Nimar.
In lateritic soil on the Deccan trap :—Satara.

Each of the three chief groups will now be considered in turn.

[1] *Rec. Geol. Surv. Ind.*, LXIV, pp. 221-233, (1930).

A.—The Gondite Group.

Gondite series.

The gondite series[1] is composed of metamorphosed manganiferous sediments of Dharwar age, and is characterised by the presence of various manganiferous silicates, the most important of which are the manganese-garnet, spessartite, and the manganese-pyroxene, rhodonite. The garnet occurs commonly as a rock composed of spessartite and quartz, and this is the rock that has been called *gondite*, after the Gonds, one of the aboriginal races of the Central Provinces. Other common rocks are spessartite-rock, rhodonite-rock, and rhodonite-quartz-rock. The series is developed typically in the districts of Balaghat, Bhandara, Chhindwara, and Nagpur, in the Central Provinces,[2] but has also been found in several other areas, namely :—Narukot State in Bombay, Jhabua in Central India, Gangpur State in Bihar and Orissa, and probably in Banswara State in Rajputana. It exists also in the Seoni district, Central Provinces.[3]

Forming an integral portion of the same masses of rock as the gonditic rocks, there are, at many places, bodies of manganese-ore, often of large size and first-rate quality, some of the manganese-ore deposits of the Central Provinces being the most valuable in India, and second to none found in other parts of the world.

Origin.

The rocks of the gondite series are supposed to have been formed by the metamorphism of a series of sediments deposited during Dharwar times. These sediments were partly mechanical (sands and clays) and partly chemical (manganese oxides). When these sediments were metamorphosed, the sands and clays were converted into quartzites, mica-phyllites and mica-schists; the purest of the manganese-oxide sediments were compacted into crystalline manganese-ores; whilst mixtures of the mechanical sediments, sand or clay, with the chemical sediment, manganese oxide, were converted into rocks composed of manganese silicates—spessartite and rhodonite—any silica left over, after accounting for the formation of these minerals, appearing as quartz. The effects of regional metamorphism have been in some

[1] *Mem. Geol. Surv. Ind.*, XXXVII, pp. 306—365, (1909).

[2] The series of Archæan schists and marbles in which the gonditic horizon occurs in the Central Provinces has been named the Sausar series. Names have also been allotted to each stage, that adopted for the gonditic horizon being the Mansar stage. Whereas the latter term is a stratigraphical term, gondite is a petrographical term. *See* L. L. Fermor, *Rec. Geol. Surv. Ind.*, LIX, pp. 77—79, (1926).

[3] R. C. Burton, *op. cit.*, XLIV, p. 21, (1914).

cases complicated by contact effects with resultant hybridism due to later intrusives.[1] The rocks thus formed constitute the *gondite series.* There is abundance of evidence to prove that the manganese-silicate-rocks of the gondite series have been subjected to extensive oxy-alteration, subsequent to their formation, but probably in Archæan times. As a result of this alteration large bodies of manganese-ore have been formed; no decisive evidence has yet been obtained indicating the relative proportions of the workable ores that are the result of the direct compression of the purer portions of the original manganese-oxide sediments[2] and of the ores that have been formed by the subsequent alteration of the rocks of the gondite series.

Nagpur-Balaghat area: mode of occurrence.

The ore-bodies thus formed occur as lenticular masses and bands intercalated in the quartzites, schists, and gneisses; and, as would be expected from the suggested mode of origin, the ore is frequently found to pass, both laterally and along the strike, into the partly altered or quite fresh members of the gondite series, the commonest rock being gondite itself. The ore bodies are often well-bedded parallel to the strike of the enclosing rocks, and several of them are often disposed along the same line of strike, indicating that they have probably all been produced from the same bed of manganiferous sediment. A good example of such a line of deposits is one in the Nagpur district, stretching from Dumri Kalan in an easterly direction as far as Khandala, a total distance of 12 miles, this line including the valuable deposits of Beldongri, Lohdongri, Kacharwahi, and Waregaon. With the enclosing rocks the ore-bodies have often suffered repeated folding, upon which is often superposed a well marked pitch, which frequently, as at Kandri and Thirori, determines the direction of mining operations.

Dimensions of ore-bodies.

The ore-bodies often attain great dimensions. The Balaghat deposit is 1¾ miles long; at Manegaon in the Nagpur district the ore-body is 1½ miles long; whilst the band running through Jamrapani, Thirori, and Ponia, in the Balaghat district, is exposed more

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XLV, p. 104, (1915).

[2] The fact that some of the gonditic manganese-ores are of great antiquity (at least pre-pegmatite in age) was conclusively proved by the discovery of a detached fragment of ore in pegmatite cutting the Gowari Warhona manganese-ore deposit, Chhindwara district. See *Rec. Geol. Surv. Ind.*, XLI, pp. 1—11, (1911). Similar phenomena were later well displayed at Sitapar in the same district, and are still to be seen at intervals at Kachhi Dhana.

TABLE 81.—*Total production of Manganese-ore from deposits of gonditic type that have yielded 100,000 tons of ore by the end of 1933.*

Mine.	District or State in which situated.	Year of commencement of work.	Total production to end of 1933.
1. Balaghat	Balaghat	1901	1,608,465
2. Thirori	Do.	1902	1,599,904
3. Kandri	Nagpur	1900	1,211,274
4. Chikhla (with Yedarbuchi)	Bhandara	1901	1,059,295
5. Mansar	Nagpur	1900	944,022
6. Kachhi Dhana	Chhindwara	1906	919,849
7. Kodegaon	Nagpur	1903	535,255
8. Gumgaon	Do.	1901	471,037
9. Sitasaongi	Bhandara	1908	430,225
10. Kurmura (with Ponwar Dongri, Dongri Buzurg, Balapur Hamesha).	Do.	1902	400,252
11. Ramrama	Balaghat	1906	359,737
12. Lohdongri	Nagpur	1900	335,409
13. Miragpur	Balaghat	1905	332,623
14. Sukli	Do.	1905	314,612
15. Gariajhor	Gangpur	1908	309,986
16. Ukua (with Samnapur and Gudma).	Balaghat	1906	238,578
17. Kajlidongri	Jhabua	1906	223,546
18. Ramdongri	Nagpur	1901	218,248
19. Netra (with Gola Hurki)	Balaghat	1908	167,995
20. Satak	Nagpur	1904	160,210
21. Shodan Hurki	Balaghat	1912	148,247
22. Junawani	Nagpur	1906	139,052
23. Manegaon	Do.	1902	131,837
24. Kosumba	Balaghat	1905	125,679
25. Kacharwahi	Nagpur	1902	121,519
26. Mandri	Do.	1902	117,870
27. Ponia	Balaghat	1906	114,887
28. Sitapathur	Do.	1906	101,724
29. Jamrapani	Do.	1906	97,736

or less continuously for nearly 6 miles. In an earlier review a thickness of 100 feet (of ore) was ascribed to the Kandri deposit, and of 1,500 feet (ore and gonditic rocks) to the Ramdongri deposit. Subsequent work indicates that both these deposits are folded, and there is no evidence that the ore-bodies are anywhere more than 45 to 50 feet thick: a greater apparent thickness appears to be due to repetition by folding. On the other hand the ore-band is often much thinner, but may have again attained a fictitious thickness due to folding. The depth to which these ore-bodies extend is unknown. It is, however, almost certain that, in many cases, they

extend to at least 100 to 400 feet below the outcrop, *e.g.*, some of the deposits occupying hills in the Central Provinces; and it is very probable that some of the Central Provinces deposits extend to depths considerably greater than these; for the evidence obtained indicates that the deposits were formed in depth, so that the position of the deposit bears no genetic relation to that of the surface. An idea of the size of some of these deposits can be obtained from the amounts of ore they have yielded, as shown in Table 81.

The total production from deposits of the gonditic type (the Central Provinces) averaged 316,533 tons annually during the quinquennium as compared with 675,472 tons annually during 1924-1928, 525,192 tons annually during 1919-1923, 504,597 tons annually during 1914-1918, and 529,152 tons during 1909-1913.

Composition of ores.

The typical ores of the Nagpur-Balaghat area of the Central Provinces consist of mixtures of braunite and psilomelane of different degrees of coarseness of grain. The most typical ore is a hard fine-grained ore composed of these two minerals. Other minerals found in the Central Provinces ores are hollandite, vredenburgite, sitaparite, and rarely pyrolusite. The unique ore of Sitapar in the Chhindwara district consisting of hollandite with sitaparite and fermorite, proved to be a surface form, and at a depth of 60 feet gave place almost entirely to braunitic ore, which persisted to the bottom of the pit at 100 feet (*see* page 235). The ores exported from the Central Provinces are mainly of first grade, but during the quinquennium moderate quantitites of second-grade ores (45 to 48 per cent. of manganese) have been produced. The chief characteristics of the first-grade ores are the high manganese contents (usually 48 to 54 per cent. as exported), moderately high iron (usually 4 to 8 per cent.), rather high silica (usually about 6 to 9 per cent. and largely due to the braunite in the ore), and moderately low phosphorus (usually about 0·07 to 0·20). For analyses *see* Table 75, pages 222, 223. At Dongri Buzurg in the Bhandara district, an ore rich in peroxide is found, yielding as exported 84 to 88 per cent. of peroxide.

Ores in crystalline limestones.

In addition to the deposits found in association with spessartite- and rhodonite-bearing rocks in the Central Provinces, manganese-ores are sometimes found in association with crystalline limestones, usually containing piedmontite, and also regarded as of Dharwar age. Ores of this character are found characteristically in the Nagpur

and Chhindwara districts. The manganese-ores occur either as lines of nodules or as fairly definite beds in the limestone, the latter being the rarer mode of occurrence. In most cases it is not found profitable to work these ores; but where the bed of ore is of greater thickness than usual, as in the Junawani forest, it may pay at times of high prices; whilst patches of residual nodules accumulated during the dwindling of limestones will pay to work at any time, if not too far removed from transport facilities. The ores found thus are usually composed of braunite and psilomelane or hollandite. These ores, and the associated crystalline limestones and calcareous granulites, are probably the products of the metamorphism of calcareous sediments with associated manganiferous ores, and are thus analogous in origin to the ores associated with the true gonditic rocks.

The remarks in the foregoing paragraphs apply particularly to the deposits found in the Central Provinces, but also in a general way to the deposits found associated with rocks of the gondite series in other parts of India. A few remarks about these are given below.

Gangpur, Bihar and Orissa.

During 1908, the extension of the gondite series into Bihar and Orissa was proved by the discovery of manganese-ore deposits in Gangpur State associated with rocks containing spessartite and rhodonite. The ores are typical gonditic ores, containing braunite in a matrix of psilomelane. The chief deposit, Gariajhor, yielded 309,986 tons of ore during the years 1908 to 1928, since when there has been no output from this deposit. As will be seen from the figures summarised in the following table, the quality of the ore is similar to that of the Central Provinces :—

—	1909.		1919-1923.	
	Limits of analyses.	Mean of analyses.	Average analysis of ore railed.	
Manganese	47·64 —54·13	50·53	49·60	45·85
Iron	5·53 — 6·35	5·85	7·82	8·29
Silica	2·6 — 8	5·7	4·96	5·04
Phosphorus	0 018— 0 143	0·089	0·205	0·144
Moisture	0·78 — 1·16	0·96	..	..

The 1909 figures relate to cargoes shipped during that year, the manganese and phosphorus figures representing eight anaylses on a total of 3,600 tons of ore, and the other constituents four analyses on a total of 1,600 tons of ore. The 1919-1923 figures, supplied by Mr. W. H. Clark, represent the first and second-grade ore as exported during the period. Estimated average figures for 1924-1928 are given in Table 69 of the previous review. These two sets of figures are of interest as illustrating the increase of phosphorus contents in gonditic ores with depth from the surface.

Narukot, Bombay.

Rocks of the gondite series with associated manganese-ore have been found in a small hill at Jothvad in Narukot State, Bombay. The occurrence is of no economic importance, but of great scientific interest. The rock surrounding the hill is a porphyritic biotite-granite presumably of Archæan age, and apophyses from this pierce the gonditic rocks of the hill. Isolated pieces of gonditic rock are included in the granite, and amongst these inclusions are pieces of manganese-ore, proving that a portion at least of the manganese-ore had been formed before the time of intrusion of the granite into the Dharwar rocks of the area.

Panch Mahals.

Manganese-ore deposits are being worked near Shivrajpur and Bamankua in the Panch Mahals. The rocks with which they are associated are Champaners, that is Dharwars; no rocks of gonditic nature have been found in this area, but it seems, judging from reports, that although a portion of the ores has certainly been formed by the superficial replacement of quartzites, a portion may have been deposited contemporaneously with the enclosing Dharwar rocks; in this case the deposits may be classified with the gonditic deposits. The absence of gonditic rocks would then mean that the rocks—as at the Balaghat deposit in the Central Provinces—had not been subjected to such intense metamorphism as that which produced the gonditic rocks associated with most of the Central Provinces deposits. 984,143 tons of ore have been won from this area in the twenty-eight years 1906 to 1933. The average composition of this ore as exported is shewn in Table 76.

Jhabua, Central India.

The chief deposit in Jhabua State was that situated at Kajlidongri. This is a true gonditic occurrence, and the rocks associated with the manganese-bearing rocks are those known as Aravallis, which are in this part

of India the equivalents of the Dharwars. In the 12 years 1903 to 1915, this deposit yielded 195,763 tons of manganese-ore, and since 1916, the deposit was abandoned. But during 1924 to 1928, 27,783 tons of ore were extracted, making a total of 223,546 tons, since then there has been no production. For the quality of the ore obtained *see* Table 75.

B.—The Kodurite Group.

Kodurite series.

The kodurite series[1] is developed typically in the Vizagapatam district, where it occurs associated with other Archæan crystalline rocks, the chief groups of which are the khondalite series including the calcareous gneisses or granulites, the gneissose granite, and the charnockite series. The kodurite series was held to be of igneous origin, and probably of later age than the khondalite series, which is the series with which it is closest associated. The original koduritic magma has been differentiated into a series of rocks ranging from very acid (quartz-orthoclase-rock) through basic (kodurite) to ultra-basic (spandite-rock and manganese-pyroxenites). The typical rock, *kodurite,* is composed of potash-felspar, spandite (a garnet intermediate in composition between spessartite and andradite), and apatite. The manganiferous nature of these koduritic rocks has been a petrological surprise, and it has consequently later been suggested[2] that they may be hybrid rocks produced by the assimilation by an acid igneous magma of manganese-ore bodies and manganese-silicate-rocks allied perhaps to the gondite series.

The manganese-bearing minerals contained in these rocks are spandite, rhodonite, and two or three other manganiferous pyroxenes, at present unnamed. Subsequently, the whole series of rocks has been chemically very much altered with the production, from the felspar, of enormous masses of lithomarges and, from the manganiferous silicates, of manganese-ores. Other secondary products are chert, ochres, and wad.

The manganese-ore bodies thus formed are often extremely irregular both in shape and size, often showing no definite strike

[1] *Mem. Geol. Surv. Ind.*, XXXVII, Chaps. XII, XIII, (1909); *Rec. Geol. Surv. Ind.*, XXXV, p. 22, (1907); *op. cit.*, XLII, p. 208, (1912); *op. cit.*, XLIII, p. 42, (1913).

[2] *Rec. Geol. Surv. Ind.*, XLVI, p. 102, (1915). Also *see* Whitman Cross, *Journ., Geol.*, XXII, pp. 791—806, (1914).

Vizagapatam: mode of occurrence.

or dip. But in other cases, as at Garbham, the ore-bodies have a well-marked dip and strike, and apparent bedding, which probably represents original banding in the parent rock; for much of the ore has been deposited so as to replace metasomatically the pre-existing rock.

Dimensions of ore-bodies.

Some of the ore-bodies are of very large size. The largest, Garbham, is some 1,600 feet long, and 167 feet thick at its thickest section, 100 feet of this thickness being ore and the remainder lithomarge, wad, etc. From the commencement of work on this deposit in 1896 to the end of 1928, Garbham has yielded the large total of 949,933 tons of ore, of which 41,254 tons were produced during 1929-1933. The only other very large deposit in this district is Kodur; but this is really a series of scattered ore-bodies in lithomarge. It has yielded 407,694 tons of ore from 1892 to 1933, of which 11,096 tons were produced in the quinquennium 1929-1933. It was the first manganese-ore deposit to be worked in India.

Composition of ores.

The ores of the Vizagapatam district are composed mainly of psilomelane with subordinate amounts of pyrolusite, braunite, manganmagnetite, and in one case (Garividi) vredenburgite. They are usually of second and third grade—although some first-grade ore has been obtained at Kodur—and can be divided into manganese-ores (above 40 per cent. Mn.) and ferruginous manganese-ores (below 40 per cent. Mn.). They are characterised by high iron and phosphorus contents, and comparatively low silica (*see* Table 76).

C.—The Lateritoid Group.

Lateritoid deposits.

In several parts of India manganese-ore deposits are found on the outcrops of rocks of Dharwar age, associated with the latter in such a manner as to leave little doubt that the ores have been formed by the replacement at the surface of Dharwar schists, phyllites, and quartzites. The masses of ore thus formed do not consist entirely of manganese-ore, but often contain considerable quantities of iron-ore; and every gradation is to be found from manganese-ores, through ferruginous manganese-ores and manganiferous iron-ores, to iron-ores. The masses of ore thus formed are often more or less cavernous and bear considerable resemblance to ordinary laterite. In fact some

geologists would designate such occurrences by this term; but others would object: and, therefore, to obviate this difficulty the term *lateritoid*—meaning *like laterite*—has been introduced to designate this class of deposits. Lateritoid deposits are, then, irregular deposits of iron- and manganese-ores, occurring on the outcrops of Dharwar rocks, and resembling in their cavernous and rugged aspect masses of ordinary laterite. When the rock replaced is a schist or phyllite, it is usually found altered to lithomarge below the capping of ores. The mineral composition of the ores thus formed is usually fairly simple. The manganese-ores are pyrolusite, psilomelane, wad, and more rarely pseudo-manganite, and manganite; whilst the iron-ores are limonite and earthy hematite. The harder crystalline minerals—braunite, vredenburgite, sitaparite, magnetite, and specular hematite—are found rarely or never in the lateritoid ores. Hollandite may sometimes occur. The chemical characteristics of the manganese-ores are high iron, low silica, and often very low phosphorus. The manganese is usually correspondingly low, so that the ores won consist mainly of second-grade manganese-ores and third-grade ferruginous manganese-ores. Such deposits will be worked to the greatest advantage when a market can be found for the iron-ores and manganiferous iron-ores, as well as for the manganese-ores.

The areas where the ores of this nature have been found are given on page 236.

In Bihar and Orissa, Singhbhum district and Keonjhar State yield ores of this nature. Singhbhum has been a trivial producer at intervals since 1906, the total production up to 1926 being only 9,779 tons. With the discovery of manganese-ores associated with the iron-ore areas of southern Singhbhum, however, the production expanded rapidly to 23,199 tons in 1928, and a total output of 51,564 tons in the present quinquennium.

Singhbhum.

Since 1923 there has been an important output of manganese-ore from the iron-ore areas of Keonjhar State, the outputs being 1,968 tons in 1923, 194,469 tons in 1924-1928, and 235,769 tons in the present quinquennium, the year of maximum production being 1933, with 60,407 tons. These ores occur at least partly as lateritoid replacements in the Iron-ore series, and are of two types, the principal ore being a metallurgical ore of moderately high iron contents (*see* Table 75), and the less

Keonjhar.

abundant a peroxide ore, with 81 to 88 per cent. of manganese-peroxide (*see* Table 76) and low iron, suitable for batteries and other chemical purposes. On account of the relative proximity of the deposits to the port of Calcutta, work on these deposits has not been affected by the slump of 1932 and 1933.

Other important lateritoid areas are Sandur and Mysore, Sandur being the most important of all. A large number of deposits, many of them of large size, have been located in the Sandur hills, mostly perched up on the edge of the hills at an average elevation of about 1,000 feet above the plains. Now that transport difficulties have been surmounted, these deposits may be expected to yield large quantities of second-grade and third-grade ores, with possibly a certain proportion of first-grade ore from the Kamataru portion of the State. The deposits are being worked by the General Sandur Mining Company, Ltd. During the years 1905 to 1914, 418,424 tons of ore were won from these deposits, mainly from the Ramandrug and Kannevihalli areas, but work was closed down during the war on account of the high ocean freights. In 1921, work was resumed by this company and 39,355 tons of ore were extracted during the quinquennium ending 1923, 451,709 tons during the quinquennium ending 1928 and 616,681 tons during the present quinquennium, making a total of 1,526,169 tons since the beginning. Kamataru or Kammatharuvu is now the chief producing deposit, being responsible for 376,187 tons during the present quinquennium. For analyses *see* Tables 75 and 76.

Sandur.

The manganese-ore deposits of Mysore are numerous, but very few of them can compare in size with those of the Sandur hills, although they have been formed in the same way. The chief exception is the Kumsi deposit in the Shimoga district from which some 160,000 tons of ore were won in the three initial years 1906 to 1908, the State as a whole yielding 223,243 tons during the same period. In the quinquennium 1909-1913, there was a great decline in output compared with that of the initial period of work, the average annual output of the State being 28,280 tons. The average annual output for subsequent quinquennia has been 24,205 tons in 1914-1918, 21,703 tons in 1919-1923, 32,046 tons in 1924-1928, and 12,087 tons in 1929-1933. The reduction of the industry to this lower level is largely due to the superficial nature of the deposits leading to early exhaustion of the

Mysore.

best class of ores, whilst high railway and sea freights prevent the exploitation of the lower-grade ores. The chief company at work in this state has been the United Steel Companies, Limited, which took over the Workington Iron Company, Ltd., in 1918: but this company has now liquidated its interests in Shimoga, and there has been no production from Kumsi since 1930.

D.—The Laterite Group.

Goa and Belgaum.

Manganese-ores are sometimes found in true laterite; but such ores are rarely of much economic value. The ores of Goa (Portuguese India) occur in part in this way (in low-level laterite), as also those of Belgaum (in high-level laterite). They are not economically of great importance owing to the irregular manner in which they occur, and their extremely variable composition. Picked ores, however, are similar in composition to the picked lateritoid ores. Only 154 tons of ore won in Goa were exported from Marmagao during the period 1919-1923 as compared with 598 tons during the war period and 16,243 tons in the previous quinquennial period. These exports are, of course, excluded from Table 66. 14,012 tons of ore have been extracted from Belgaum during the years 1925 to 1928, and 11,496 tons during the present quinquennium.

No figures have been obtained of the production of manganese-ore in Goa during the last two quinquennial periods.

Mica.

[Cyril S. Fox.]

Introduction.

The mineralogical aspects of mica are given in all text-books of mineralogy. Reference to such works will show that there are several varieties of mica, and that a characteristic property of most micas is a highly developed cleavage whereby thin sheets or films of mica can be readily produced. The chief micas of commercial value are those which are practically transparent in relatively thin plates. These may be pale-tinted and clear or only slightly stained and spotted. The two chief varieties of commerce are *muscovite* and *phlogopite*. With the exception of a very small production of phlogopite from the

TABLE 82.—*Provincial Production of Mica in India during the years 1929 to 1933.*

Province.	1929		1930		1931		1932		1933	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Cwts.	*Rs.*	Cwts.	*Rs.*	Cwts.	*Rs.*	Cwts.	*Rs.*	Cwts.	*Rs.*
Bihar and Orissa	42,560	*20,77,754*	40.887	*19,92,204*	31,720	*16,69,720*	24,097	*10,35,466*	32,674	*12,59,180*
Gwalior	25	*1,776*	..	..	..	..	..	..	..	..
Madras	10.194	*5,56,060*	11,348	*6,53,761*	6.958	*3.52,030*	8,369	*3,89,925*	8,005	*4,09,737*
Rajputana	452	*24.169*	492	*23.021*	285	*15,884*	247	*10,010*	396	*13,128*
TOTAL	**53,231**	*26,59,759*	**52,727**	*26,68,986*	**38,963**	*20,37,634*	**32,713**	*14,35,401*	**41,075**	*16,82,045*
Value in Sterling		*£198,489* (£1 = Rs. 13·4)		*£197,703* (£1 = Rs. 13·5)		*£150,935* (£1 = Rs. 13·5)		*£107,925* (£1 = Rs. 13·3)		*£126,470* (£1 = Rs. 13·3)

workings in Travancore, nearly all the mica extracted from the pegmatitic rocks of the mica occurrences of India belongs to the variety known as muscovite.

Production.

During the period under review the output of mica in India averaged 43,742 cwts. against 43,309 during the period 1924-1928, with a minimum output of 32,713 cwts. in 1932 (*see* Table 82). As usual the chief producing province was Bihar and Orissa, with an important output from Madras, and small outputs from Rajputana and Gwalior. As these totals are considerably smaller than the recorded exports (*see* Table 83) the method of recording the output of mica from the mines needs explanation. The figures supplied by various mining companies and other producers are the totals of all the cut mica obtained in their cutting and sorting sheds. No details are given, and there seems to be no mention of the rough mica from which the cut mica is obtained. In such circumstances, there must be considerable confusion if the rough mica is purchased from small vendors and cut and sold by dealers who have no mines and who, consequently, send in no returns—a condition which prevailed till recently.

Exports.

For the past 40 years India has been a great exporter of mica. Practically all the mica obtained from Indian mines is despatched to Europe and America. During the quinquennium 1929-1933, the average annual exports of Indian mica have been 71,338 cwts. against 86,541 cwts. during the quinquennium 1924-1928. These exports which in 1929 were twice the recorded output of the mines, were only 40 per cent. larger in 1933: in consequence, it is difficult to gauge the domestic consumption of mica. It has been estimated that the amount of cut mica, chiefly the larger sizes (above No. 4's), utilised in India, is less than 2,000 cwts. annually, but this estimate is obviously a guess, as no detailed returns appear to be available. Nevertheless, it may be assumed that practically all the mica produced from Indian mines and prepared in the form of cut mica, usually as mica splittings, is exported.

The exported quantities of Indian mica are shown in the accompanying tables (*see* Tables 83 and 84), which show the exports of Indian mica during the periods 1924-1928 and 1929-1933, and to what countries consigned.

TABLE 83.—*Exports of Indian Mica during the years 1929 to 1933.*

—		1929.	1930.	1931.	1932.	1933.
Blocks	Cwts.	17,799	14,824	8,276	6,693	16,772
	Rs.	41,40,349	28,61,021	14,95,203	13,82,135	24,29,357
Splittings	Cwts.	98,276	68,085	44,690	40,328	40,945
	Rs.	63,66,485	47,26,710	26,53,565	19,66,808	16,62,676
TOTAL	Cwts.	116,075	82,909	52,966	47,021	57,717
	Rs.	1,05,06,834	75,87,731	41,48,768	33,48,943	40,92,033

TABLE 84.—*Destination of exported Indian Mica.*

—		1929.	1930.	1931.	1932.	1933.
United Kingdom	Cwts.	40,132	33,478	22,891	22,389	23,575
	Rs.	42,89,252	35,02,623	24,05,167	18,60,262	22,68,698
United States	Cwts.	48,348	28,982	12,378	11,264	19,812
	Rs.	43,76,606	25,26,164	7,18,550	5,44,569	8,94,821
Germany	Cwts.	10,190	7,788	3,831	5,013	6,161
	Rs.	6,19,395	4,86,562	2,00,931	2,39,505	3,20,961
France	Cwts.	7,506	5,050	4,810	788	1,067
	Rs	4,66,624	3,08,179	97,992	87,719	79,331
Other countries	Cwts.	9,899	7,611	9,056	7,567	7,102
	Rs.	7,54,957	6,79,203	7,26,128	6,16,888	5,28,222

It is evident from these returns that the export trade in Indian mica has, during the last three years shared in the general depression both in quantity and value. Owing to the lack of details regarding the sizes and qualities of the mica exported, either as block mica or mica splittings, it is impossible to follow the true fluctuations of the demand; but taken as a whole for each year, the declared values of the consignments have varied as follows: in 1924, the average value was a little over Rs. 135 per cwt. (roughly Rs. 1-3-3 per lb.); in 1928, it was nearly Rs. 98 per cwt. (about Re. 0-14-5 per lb.); in 1929, the value was roughly Rs. 90-8-0 per cwt. (nearly Re. 0-12-10 per lb.); and in 1933, nearly Rs. 71-12-0 per cwt. (nearly Re. 0-10-3 per lb.). These are declared values at the time of export and, for the past decade, may be assumed at, roughly, Re. 0-13-0 per lb. However, these computations are not a true index of the prices actually obtained by the vendors. In the Bihar 'mica belt', mica may be purchased locally at prices considerably lower, perhaps, than Re. 0-11-0 per lb. (on lots of mixed cut mica). Brokers in Europe and America pay more than Re. 0-13-0 per lb. exclusive of freight. Finally, the consumers in Europe and America are believed to pay on an average Rs. 1-8-0 per lb. inclusive of freight, etc., for the material they buy at relatively short notice.

Value.

In Table 85 the production, in long tons, of mica from all countries is shown for the period 1924 to 1933. From these returns it is clear that the tonnage of mica produced and exported from India is barely 25 per cent. of the world totals of the last few years. This is largely due to the fact that no scrap mica is recorded in the Indian production. The only mica of which statistics are available from India is that known as block mica and mica splittings of sizes from one square inch upwards. In other countries, particularly in the United States of America, large quantities of low grade mica find a sale in the preparation of mica powder, etc. The value of this low grade material is small. The relative value of the Indian output of mica is better seen from Table 86 showing the value of mica raised in the three principal producing countries—India, Canada and the United States during the past 25 years from 1909 to 1933. It should, however, be pointed out that the production from the Union of South Africa has, since 1924, grown to important dimensions until this country, as shown in Table 85, is now fourth on the list of great producers,

Value of world output.

TABLE 85.—*World's production of Mica during the years 1924 to 1933.*

(Long Tons.)

Producing Country.	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933
British Empire.										
Kenya	..	..	..	..	..	2	..	..	..	..
Northern Rhodesia	..	1	4	8	4	3	4	1	..	1
Southern Rhodesia	134	130	163	(e) 202	183	169	162	66	13	..
South West Africa (lithium mica)	..	..	.	..	..	..	250	100	..	4
Tanganyika Territory	55	68	52	42	33	29	21	9	12	11
Union of South Africa	892	1,054	1,130	1,660	3,572	1,525	878	843	242	391
Canada	(a) 3,653	(a) 3,589	(a) 2,272	2,445	3,268	3,619	1,045	1,195	277	843
India (b)	3,505	4,985	4,497	3,874	4,774	5,804	4,145	2,648	2,351	2,886
Australia	2	4	11	5	12	46	26	29	30	42
Ceylon	..	..	..	..	..	1	..	(b) 2	(b) 2	..
TOTAL	8,241	9,831	8,129	8,236	11,846	11,198	6,531	4,893	2,927	3,178
Foreign Countries.										
France (lithium mica)	..	..	246	300	1,000	1,502	.	900	..	..
Germany (lithium mica)	..	493	654	506	265	777	773	404	(d)	..
Norway (b)	..	23	41	8	84	58	48	15	31	5
Portugal (lithium mica)	..	(d)	184	379	336	740	269	564	2,014	870
Russia	..	190	478	1,581	1,469	..	..	..	..	..
Sweden	4	93	52	10	12	65	72	64	60	..
Madagascar	281	282	325	(b) 535	841	370	342	231	136	..
United States (c)	4,856	9,457	7,258	6,282	7,680	6,492	6,665	6,342	6,437	7,976
Argentine	(b) 118	(b) 117	(b) 83	104	118	117	98	50	54	..
Brazil	(b) 78	(b) 64	51	39	74	44	(b) 51	(b) 54	(b) 41	..
Japan	582	1,065	..	..	..	..	..	..	..	..
Korea	23	20	16	(d)	28	22	28	17	20	..
Czechoslovakia (lithium mica)	..	..	..	..	..	..	30	7	(d)	..
Guatemala	..	16	12	7	13	2	..	..	..	..
TOTAL	5,942	11,820	9,400	9,841	11,920	10,189	8,376	8,648	8,793	8,851
GRAND TOTAL	14,183	21,651	17,529	18,077	23,766	21,387	14,907	(f) 13,541	(g) 11,720	12,029

(a) Shipments. (b) Exports. (c) Sales. (d) Not available.
(e) Includes 19 tons of lithium mica. (f) Excludes 12 tons in Italy. (g) Excludes 9 tons in Italy.

TABLE 86.—*Value of Mica raised in the three principal producing countries during the twenty years 1914 to 1933.*

—	Canada.	India (a).	United States of America.	Total.	India's per cent. of this total.
	£	£	£	£	
1914	22,410	191,066	67,801	281,277	67·92
1915	18,885	208,496	88,106	315,487	66·08
1916	25,180	341,255	122,139	488,574	69·84
1917	44,803	575,285	155,624	775,712	74·16
1918	55,147	598,971	157,185	811,303	73·82
TOTAL	**166,425**	**1,915,073**	**590,855**	**2,672,353**	..
Average	*33,285*	*383,015*	*118,171*	*534,471*	*71·66*
1919	56,260	750,824	111,302	918,386	81·75
1920	77,267	1,065,438	146,715	1,289,420	82·63
1921	15,768	426,274	36,034	478,076	89·16
1922	31,288	385,683	63,361	480,332	80·29
1923	67,189	538,485	90,594	696,218	77·33
TOTAL	**247,772**	**3,166,654**	**448,006**	**3,862,432**	..
Average	*49,554*	*633,331*	*89,601*	*772,486*	*81·99*
1924	73,415	679,796	61,497	814,708	83·44
1925	53,727	799,483	101,818	955,028	83·71
1926	47,098	820,901	110,311	978,310	83·91
1927	35,832	691,341	66,294	793,467	87·14
1928	17,912	698,130	74,669	790,711	88·29
TOTAL	**227,984**	**3,689,651**	**414,589**	**4,332,224**	..
Average	*45,597*	*737,930*	*82,918*	*866,445*	*85·17*
1929	24,360	784,092	83,062	891,514	87·95
1930	19,727	562,054	58,853	640,634	87·73
1931	11,110	307,316	43,408	361,834	84·93
1932	1,403	251,800	26,643	279,846	89·97
1933	9,880	307,671	31,098	348,649	88·24
TOTAL	**66,480**	**2,212,933**	**243,064**	**2,522,477**	..
Average	*13,296*	*442,587*	*48,612*	*504,495*	*87·72*

(a) Export values.

Block mica and splittings.

Since the period of the Great War, largely as a result of the demands of the electrical industry, there has been an immense increase in the consumption of mica splittings, chiefly of sizes No. 5 and smaller. The larger sizes (No. 4 up to Special) have a limited but steady market, except that there was an abnormally small export in 1931 and 1932 in conformity with the slump, as shown in Table 83 and although by weight block mica accounted for only 18 per cent. of the exports during the five years 1929 to 1933, by value block mica accounted for over 41 per cent. of the exports, the values for block mica and splittings averaging respectively Rs. 191 and Rs. 59 per cwt.

Chief consumers.

During the quinquennium 1929-1933, there was a large fall in the exports of Indian mica to all destinations, with minima in 1931 and 1932 in conformity with the world-wide depression in trade. Except in 1929, when the United States took the largest quantity, the United Kingdom was the largest buyer of Indian mica.

Localities.

By far the greater quantity of mica is obtained from the workings in the so-called Bihar mica belt, which trends across parts of the districts of Hazaribagh, Gaya and Monghyr. Almost all the mica from that region finds its way to Calcutta and is shipped from that port. The output of mica from the Nellore mines of Madras is normally exported from the port of Madras, while the annual production from Rajputana and Mysore usually finds its way to Bombay, where it is finally shipped for export abroad. Bihar and Orissa being the largest producer of mica, as seen from the table of production, it is evident that the exports will be largest from the port of Calcutta.

Imports.

During the last decade there are returns (*see* Table 87 below) which show that a certain amount of mica—chiefly block mica—has been *imported* into India from the United Kingdom, the United States, and Japan. This mica, whether it be Indian mica returned to this country or foreign mica, was received for conversion into fine splittings and was then re-exported as splittings of Indian mica; but the trade is now almost dead. The production of fine splittings by hand is an art which is performed to perfection in India and is carried out at considerably less expense than would be possible in European countries.

TABLE 87.—*Imports of Mica during the years 1924 to 1933.*

—		1924	1925	1926	1927	1928	1929	1930	1931	1932	1933
Blocks	Cwts.	1,429	4,654	918	1,568	337	1,263	626	410	148	374
	Rs.	*1,84,912*	*5,61,680*	*1,60,045*	*1,42,567*	*60,912*	*54,514*	*75,078*	*1,09,684*	*14,649*	*27,381*
Splittings	Cwts.	89	96	256	76	443	45	384	257	47	2
	Rs.	*21,060*	*10,906*	*54,618*	*7,940*	*17,028*	*1,824*	*42,407*	*18,608*	*5,271*	*793*
TOTAL	Cwts.	1,518	4,750	1,174	1,644	780	1,308	1,010	667	195	376
	Rs.	*2,05,992*	*5,72,586*	*2,14,663*	*1,50,507*	*77,940*	*56,338*	*1,17,485*	*1,28,292*	*19,920*	*28,174*

In few publications has there been any adequate discussion of the complexities of the Indian mica trade, and particularly of that large proportion of it which originates in the mines of Bihar (Hazaribagh) and is sent overseas, *viâ* Calcutta. It has been hinted on several occasions that the discrepancy between the recorded output of the mines and the export returns is chiefly due to the present methods of trading in mica—especially in the area between Kodarma and Giridih. The number of convictions for theft of mica show that several mining companies, usually the larger ones, must suffer loss from pilfering. Their mines are in lonely forest areas, their stores are occasionally two miles away, and the transport of the day's output (bundles of *rough* mica) is generally made after dusk. It is impossible to guess how large is the leakage *en route* if the guards connive at the traffic. The receivers of this stolen mica may or may not be owners of small mines; they may not be classed, unrestrictedly, with the many vendors of *cut* mica (either dressed block-mica or splittings), from whom local purchases can be made openly. The local dealing in mica is of long standing and has frequently been of considerable convenience even to the biggest vendors; it has enabled them to procure certain sizes and qualities of mica to meet orders which they could not have met from their own mines. Although it is sometimes very difficult for a vendor to state precisely the source of origin of his mica, he can usually do so if proper records are kept.

Illicit dealing.

The local Government of Bihar and Orissa, in consultation with the Director of the Geological Survey and the Chief Inspector of Mines, framed certain rules in 1927 which aimed at restricting the illicit trade in mica. When these measures were placed before the provincial Legislative Assembly they were rejected and consequently did not become law. The bill was subsequently amended and became law under the Bihar and Orissa Mica Act of 1932 and applied to the district of Hazaribagh since May, 1932 and to the police station Rajauli in the Gaya district in 1933. Proposals have recently been put forward to extend the Act to the whole mica-producing country, but it has not been possible to do so owing to lack of funds. The working of the Act is proving more and more helpful to legitimate traders in mica and has reduced thefts considerably. The police have done the best they could with the available funds

The Bihar and Orissa Mica Act, 1932.

in convicting irregular dealers and in compelling others to show the sources of their mica purchases. However, there seems to be little doubt that the Act must be more widely applied and that it can only be worked more effectively with larger funds. The smaller differences in 1931 to 1933 between production and exports may be due to the operation of this Act.

Indian mica occurrences.

The chief mica mining areas in India are those of Hazaribagh in Bihar and of Nellore in Madras. Mica has also been obtained from workings in the Eranial *taluk* of Travancore, the Hassan district of Mysore and Ajmer in Rajputana.

The 'mica belt' of Bihar obliquely traverses the districts of Gaya, Hazaribagh and Monghyr, along a strip about 12 miles broad and over 60 miles long. A large number of the more important workings are situated either in, or in the vicinity of the Kodarma forest. The local names of Kodarma, Domchanch, Dhab, Gawan, Tisri, etc., are familiar to mica dealers in London and elsewhere. By far the larger proportion of the Indian output of mica is obtained from the Bihar mica belt, although the mica is often commercially spoken of as Bengal mica or Bengal ruby mica[1] because the sheets in sufficient thickness have a beautiful ruby colour—a characteristic of the muscovite from the Hazaribagh district. Another but secondary characteristic of the area is the fact that garnets found in association with mica in Bihar occur in the crystal habit known as the icosatetrahedron.

The mica mines of the Nellore district of Madras are situated on the eastern half of the Madras coastal plain between latitudes 14° and 15°, over a tract of country some 60 miles long and 8 to 10 miles broad. As in the Bihar belt, where beside primitive burrowings there are modern mines, so in the Nellore district, although the great majority of the mines are merely open quarries, Tellabodu, Kalichedu and some other mines are worked on up-to-date lines. Madras mica generally has a characteristic green colour thought to be due to traces of chromium in the muscovite from that area. However, brown mica, not unlike ruby, occurs at Kalichedu and along the pegmatite strike there. Associated with the mica are, as will be seen below, several minerals, amongst which are to be seen garnet crystals in the dodecahedral habit. The garnets of

[1] Dating from the days before the province of Bihar and Orissa was formed.

both Nellore and Hazaribagh are of the same variety although they have different crystal shapes.

The distinction which is apparent in the prevalent methods of working in Bihar and Madras, is also noticeable in the preparation of mica for the market in the two areas. In the Bihar belt all the mica is sickle-trimmed into irregularly shaped blocks, while the Nellore mica is trimmed by shears into rectangular shapes and classified and sized with meticulous care for excise purposes. The Bihar block mica is thicker than the shear-trimmed Madras material.

There is a great similarity in the mode of occurrence of mica in pegmatites throughout India. A description of the mining operations undertaken by the Geological Survey of India at Jorasemar near Kodarma on behalf of the Ministry of Munitions, London, were given in the last Quinquennial Review (*Rec. Geol. Surv. Ind.*, LXIV, pp. 245-250, (1930)).

Uses of mica.

It is unnecessary to state in detail the various purposes for which mica is required. Sheet mica has been largely used for stove and furnace windows, for gas lamp chimneys and shades, etc., but the chief use is for electrical purposes as an insulator, *e.g.*, for separating commutator segments in dynamos, for electric heaters and cookers, in electric condensers, as washers in sparking plugs, bolts and screws, etc. Formerly size No. 5 was the smallest piece of sheet mica utilised; during the war the utility of smaller sheets (No. 6) was demonstrated, and now size No. 7 is a marketable product. This is largely due to the development of the micanite industry. *Micanite* is really the built-up sheets of the smallest, thinnest films of mica which are cemented together with shellac dissolved in spirit. The 'made' sheets can be built to any size and thickness. They require to be steamed, pressed and rolled and in the pressing can be moulded to almost any desired shape.

Mention was made of the fact that, although India is the largest producer of mica in the world, practically the whole output is exported. Attention was also drawn to the fact that mica splittings are most cheaply and efficiently made in India. When it is remembered that India holds a monopoly in the production of shellac it is difficult to understand why this country does not hold a predominant position in the manufacture of micanite.

There are numerous published papers which deal with the mica occurrences of India, the British Empire and other countries, and

with questions of the marketing of mica generally. Amongst these are the Quinquennial and Annual Reviews of Mineral Production by the Director of the Geological Survey of India (published in the Records of the Department); Sir Thomas Holland's monograph on Mica (*Mem. Geol. Surv. Ind.*. XXXIV, Pt. 2): T. H. La Touche's Annotated Index of Indian Minerals of Economic Value; Dr. J. Coggin Brown's compilation on the trade and marketing of mica (Bull. No. 15, Indian Industries and Labour); the brochure on 'Mica' issued by the Imperial Mineral Resources Bureau; a pamphlet on 'Mica' by Oliver Bowles (Serial No 2357, Reports of Investigations, Bureau of Mines, Department of the Interior, U. S. A.); and a 'Note on the Marketing and Utilization of Mica' by G. Vernon Hobson (Bull. No. 40, Indian Industries and Labour) and also his paper 'Mica and its International Relationships' [*Trans. Inst. Min. Met.*, Vol. XXXVI, pp. 337—395, (1927)].

Conclusion.

Mr. Hobson's note referred to above is probably the most valuable contribution by an inspecting officer on the subject of the utilisation of Indian mica. He made a careful examination of the mica occurrences in India and subsequently (1927) continued his investigations in the United States, Canada and Great Britain. In the United States, his enquiries extended to some of the largest consumers of mica. In Canada, he visited the following phlogopite mica mines:—the Lacey mine, near Sydenham Ontario, and the Blackburn mine in the neighbourhood of Buckingham, near Ottawa. In Great Britain, besides consulting various large consumers, he followed the writer's example by visiting the great micanite works at Walthamstow. With this experience and knowledge, Mr. Hobson, in a considered summary [Bull. No. 40, Indian Industries and Labour, p. 17, (1928)], says:—

'To summarise the situation, it appears reasonably certain that the market for mica will be a steadily increasing one and that the demand for splittings will increase at the expense, to some extent, of that for block mica.'

'The Indian position in the market is still one of great strength, the increase in the demand for splittings contributing very considerably to this strength. The demand frequently made by consumers for Indian mica only, is often based, not on any intrinsic superiority of Indian mica over that from other countries, but on the more satisfactory grading and marketing of the product. It is pointed out, however, that other countries are now alive to these facts and the Indian producer must not, because of the commanding hold India has on the market, be led to relax his efforts, instead he should by constant attempts improve the condition in which his product is marketed, so as to offset the growing competition from other countries.'

'It is necessary that immediate steps should be taken, by the proper authority, to ensure the protection against illegitimate trading that the producer may fairly look for, and thereby dissipate the feeling of doubt as to the security of future Indian supplies that is spreading among consumers; for consumers may otherwise turn their attention to other sources of supply.'

'The producer, when thus protected should, as the owners of the natural asset have a right to expect, turn his attention to more up-to-date methods of exploitation and should no longer be content, or be allowed, to remove the superficial mica in the cheapest possible way, if thereby the hazard and expense of future work be increased.'

'At present the elimination of the broker does not appear practicable, but producers by the avoidance of certain business methods and practices, as enumerated, can do much to foster direct trading. With the elimination of mutual distrust amongst producers and the growth of a spirit of mutual help the development of a scheme of co-operative marketing appears to offer distinct possibilities; whilst trade propaganda to encourage the wider use of mica appears to be a logical amplification of the publicity work undertaken by the mica-plate manufacturing firms, which only partially covers the field.'

During most of the period under review the Indian mica industry has passed through an abnormally bad slump due to a serious falling off in demand for block mica and especially splittings, with a corresponding fall in prices. There are, however, signs of definite improvement particularly in regard to the export of block mica. Most of the depression can be traced to the suspension of work on big electrical schemes coupled with the fluctuation in foreign exchange, but these adverse factors are gradually giving way to better trade. The mica industry in India looks forward to a considerable improvement both in trade and the working conditions in the mica areas during the next quinquennial period.

Monazite.

[L. L. Fermor.]

Uses.

Monazite, an anhydrous phosphate of the rare earths of the cerium group, including especially cerium, lanthanum, and didymium, owes its economic value to the small and variable percentage of thorium oxide that it contains. Although a market is being developed for some of the other rare earths in special types of arc-lamp electrodes and in the manufacture of special optical glasses, the thoria content is that which gives the mineral its commercial importance. This thoria constitutes the raw material in the preparation of thorium nitrate used in the manufacture of incandescent gas mantles. The

percentage of thoria in monazite varies between 1 and 12, but mineral containing less than 3½ per cent. cannot be used remuneratively in the manufacture of thorium nitrate. Whilst the demand for thorium for gas mantles has decreased owing to the competition of electric lighting, the use of cerium for pyrophoric alloys (misch metal), and of thorium in radio tubes has maintained a demand for monazite.

Sources of the world's supply.

Up to the year 1895, the whole of the world's supply of monazite was derived directly or indirectly from the Carolina deposits worked principally by the Welsbach Light Company of New York. In 1895, the sands of the Brazilian coast were first worked by the German Thorium Syndicate and the Austrian Welsbach Company and caused keen competition. The Brazilian deposits being very uniform and considerably richer and more easily available than the Carolina deposits, the American company was forced to suspend operations in May, 1910, and practically the whole demand was met by the German and Austrian companies under agreement together. Owing to its occurrence on the sea-shore of Brazil and the very low cost of transport, the German Thorium Syndicate was able to lower the market price of thorium very considerably in spite of the fact that they paid, according to report, about half their profits in royalties to the Government of Brazil. Most of the production from the ore was exported to Germany.

The Brazilian industry, being in the hands of Germans and Austrians, declined as soon as the war broke out, and in 1916 the production was *nil.* The recovery subsequent to that year was of a spasmodic nature. In 1920, the last year for which figures are available, the Brazilian output amounted to 1,153 metric tons, but in the previous year the amount was only 146 tons. The average for the four years 1919-1922 was about 437 metric tons; since 1923 no production has been reported but quantities up to 200 long tons were exported. There have been exports of 88, 15 and 295 tons in 1929, 1930 and 1932 respectively. The United States industry was always very small and no statistics have been published since 1917; a small export of gas mantles has however persisted. The chief exporters of gas mantles are Germany, the United Kingdom, and the United States, whilst by far the most important importer of gas mantles appears to be India, the average annual value of these imports for the quinquennium under review being £47,741.

Travancore monazite.

Early in the century monazite was proved by the Imperial Institute to occur in association with the much more valuable thorianite and thorite in Ceylon. The total production of thorium-bearing minerals from that country, however, up to and during 1922, amounted only to some 311 tons. In 1909, monazite-bearing sands were discovered by Mr. C. W. Schomburg of the London Cosmopolitan Mining Syndicate on the Travancore coast. Mr. Tipper, who inspected the deposits, states that the mineral is known with certainty to occur in pegmatite intrusions but is probably mainly derived from the gneisses of the Travancore hills. The mineral occurs in small, round, amber-coloured grains varying from 0·1 to 0·2 millimetres in diameter. Its density is 5·191 and its refractory index is also very high. The best means for identification in the field is a Browning direct-vision spectroscope in which the didymium lines can be observed. The mineral forms one of the constituents of the sands along the sea-shore, and contains between 8·8 and 10·08 per cent. of thoria. India possesses by far the largest reserves of monazite known in the world, and these, as regards quality measured in terms of thoria contents, are superior to any others. In certain places selective action by the waves on the sands has led to the concentration of large quantities of monazite. By mechanical means this sand can be further concentrated.[1] Work was commenced in 1911, by the London Cosmopolitan Mining Company. This was replaced by the Travancore Minerals Company who as a result of the war had been purged of their German interests. Thorium Limited also held a concession, but ceased operations during the previous quinquennium. Messrs. Hopkin & Williams are still producing.

During 1921, the production figure reached 1,260 tons, valued at nearly £31,000, but fell to 1 cwt. in 1925. The decline in the monazite industry has been world-wide and due to the supplanting of incandescent mantles for gas-lighting by electricity. There has been an appreciable revival since 1925, due to the increasing demand for ilmenite (*q.v.*), a mineral associated with monazite and formerly obtained as a kind of by-product with the collection of the latter. The ilmenite is now the principal product however. The average annual output of monazite in India during the previous five years amounted to 214 tons worth £3,060, whilst in the present

[1] *Rec. Geol. Surv. Ind.*, XLIV, p. 286, (1914).

quinquennium it has varied between 14 tons valued at £140 in 1930 and 654·3 tons valued at £6,147 in 1932, the average for the period being 215 tons valued at £2,114. The mineral is exported to New York, Paris and Hamburg.

The output and value of the past 10 years are shown in the following table :—

TABLE 83.—*Production of Monazite in Travancore State.*

Year.	Quantity.	*Value.*
	Tons.	£
1924	622·3	*9,301*
1925	(*a*)	..
1926	64·2	*947*
1927	280·0	*3,810*
1928	103·4	*1,242*
1929	180·0	*1,800*
1930	14·0	*140*
1931	89·6	*890*
1932	654·3	*6,147*
1933	139·0	*1,592*

(*a*) The production amounted to 1 cwt. only.

Monazite also occurs in the sands to the east of Cape Comorin in the Tinnevelly district and again near Waltair in Vizagapatam.

Other Indian localities.

A crystalline variety containing only $2\frac{1}{4}$ per cent. of thorium has been found in pegmatites of the Bangalore district, Mysore State.[1]

A large number of beautiful crystals of this mineral have been found with pitchblende and columbite in pegmatites in the Gaya district, Bihar and Orissa.[2] It has also been found in minute quantities in concentrates from Tavoy and Mergui.[3]

Thorianite ?—A black mineral doubtfully identified with thorianite has been discovered at Thadagay Hill, (77° 32′ : 8° 16′) Travancore. The mineral is apparently isometric. The specific gravity is extremely high, namely 10·03. Owing to the paucity of material a partial analysis only could be made, and this gave as the principal constituents, thoria 32·3 per cent. and uranium oxide 39·9 per cent. The identity with thorianite is very doubtful and it might easily be a variety of uraninite. More is required to be known of this interesting find.

[1] Mineral Resources of the Mysore State, p. 191, (1916).
[2] *Rec. Geol. Surv. Ind.*, L, p. 255, (1919).
[3] *Op. cit.*, XLVIII, p. 179, (1917).

Nickel.

[L. L. FERMOR.]

Ores of nickel (nickeliferous pyrrhotite) have been found amongst the copper-ores of Khetri and other places in Rajputana. Nickel has also been detected in small quantities in chalcopyrite and pyrrhotite found associated with the gold-quartz reefs of Kolar, and in pyrite said to be from the Henzada district of Burma.

Complex sulphide ores, consisting of pyrrhotite, pyrite, chalcopyrite, and molybdenite, were received some years ago from the Tovala *taluk* in South Travancore. Both nickel and cobalt are present in quantities beyond mere traces, but nothing is yet known as to the extent of the deposits, nor have any proper average samples been assayed. A surface sample of ore showed 1·20 per cent. of copper, 0·64 per cent. of nickel, and 0·08 per cent. of cobalt, with 12 grains per ton of gold and 2 dwts. 12 grs. per ton of silver. Further investigations might show that the deposits are richer than is indicated by this analysis.[1]

TABLE 89.—*Quantity and value of Nickel-speiss produced by the Burma Corporation, Ltd.*

Year.	Tons.	Rs.	£
1929	3,065	6,38,780	47,670
1930	3,150	7,26,163	53,790
1931	2,911	6,73,973	49,924
1932	3,580	10,27,677	77,269
1933	3,350	10,28,523	77,333
Average .	*3,211*	*8,19,023*	*61,197*

There is a steady considerable consumption of nickel in India in the form of German-silver, the annual imports of which during the five years 1929 to 1933 amounted to an average of 835 tons valued at £95,889 compared with an average of 1,103 tons with £127,447 during the five years 1903-04 to 1907-08, the period first recorded in these reviews.

On the 1st August, 1907, the issue to the public was commenced of the new 1-anna nickel coinage, consisting of an alloy of 25 parts of nickel with 75 of copper, leading to a further consumption of nickel. The consumption of nickel in coinage was still further

[1] *Rec. Geol. Surv. Ind.*, XXXIX, p. 265, (1910).

increased owing to the introduction of the 2-anna and 4-anna pieces: an 8-anna piece of the same alloy was put into circulation but has been withdrawn. The imports of nickel received at the Bombay Mint in 1919-20 and 1920-21, totalled more than 2,784 tons, valued at Rs. 85,74,038; those at the Calcutta Mint amounted to nearly 1,129 tons, valued at Rs. 34,65,234. No nickel was imported between the years 1921-22 and 1928-29, or in the present quinquennium.

As a by-product in the smelting operations of the Burma Corporation, Ltd., at Namtu, in the Northern Shan States, the regular production of nickel-speiss was initiated in 1927, during which the quantity obtained amounted to 1,032 tons valued at Rs. 1,76,554 (£13,176); the speiss contained 24·64 per cent. of nickel, 15·92 per cent. of copper and also 33·58 oz. of silver to the ton. The production in 1928, rose to 2,933 tons, averaging 24·8 per cent. of nickel, 15·2 per cent. of copper and containing 32·2 oz. of silver to the ton; the value of the production in 1928, is estimated at Rs. 5,34,961 (£39,922). The output of nickel-speiss during the period 1929-1933 is shown in Table 89 and averaged 3,211 tons annually valued at Rs. 8,19,023 (£61,197). The 1933 production averaged 29·04 per cent. of nickel, 11·0 per cent. of copper and 26·60 oz. of silver to the ton. This speiss, which contains from 3 to 4 per cent. of cobalt, is shipped to Hamburg for further treatment.

Nickel also occurs in the copper-ores of Singhbhum in Chota Nagpur where three species of nickeliferous sulphides have been recognised (*see* p. 85). On the figures of 1934, the average amount of nickel in the copper-ore is however only 0·0833 per cent. or 3·4 tons of nickel per 100 tons of copper and of this only 13 per cent. is recovered in the refined copper, which averages 0·649 per cent. of nickel, whilst the balance is mainly lost in the mill in the flotation process.

Petroleum.

[E. J. BRADSHAW.]

Total production.

The total production of petroleum in the Indian Empire during the five-year period 1929 to 1933 was the largest in the history of the industry, and exceeded that of the preceding quinquennium by some 85 million gallons. The average annual production was 307,362,401 gallons with a peak production in 1930 of 311,030,108 gallons against 290,321,036

during the previous quinquennium. The peak years of earlier periods were:— 1916, with a production of 297,189,787 gallons; 1919, with a production of 305,749,138 gallons; 1921, with a production of 305,683,227 gallons; and 1928, with a, then, maximum production of 305,943,711 gallons. During the period now under review the 1928 total was exceeded in four years out of the five and the remaining year, 1931, was only short of the previous maximum by 924,960 gallons. The average annual production during the period under review exceeded the 1928 production by 1,418,690 gallons. Table 90 shows the production of petroleum in India during the years 1929 to 1933, together with its value. The rupee values are as supplied by the Local Governments. In the case of Burma the value is based on the prices at which the large refiners purchase crude petroleum from *twinzas* and other small producers who do not refine their own oil. It must be understood that the oil upon which the values are based is but a small proportion of the total output, as no well-head values are obtained from companies that refine their own oil. Variations in the reported values of the annual production are therefore not as reliable in indicating market trends as the variations in quinquennial averages. From this point of view it will be seen that the values during the present quinquennium have been remarkably steady with an average annual figure o £4,319,280; but that as compared with the previous quinquennium, for which the annual value fell from £7,559,233 in 1924 to £4,314,207 in 1928 with an average annual value of £6,268,229, this period has been one of relatively low values

TABLE 90.—*Production of Petroleum in India during the years 1929 to 1933.*

—	Quantity.		*Value.*	
	Gallons.	*Metric tons* (*a*)	Rs.	£
1929 . . .	306,148,093	1,229,510	*6,43,26,009*	(*b*) 4,800,448
1930 . . .	311,030,108	1,249,117	*5,24,97,812*	(*c*) 3,888,727
1931 . . .	305,018,751	1,224,975	*5,91,35,250*	(*c*) 4,380,389
1932 . . .	308,606,031	1,239,382	*5,07,91,038*	(*d*) 3,818,875
1933 . . .	306,009,022	1,228,952	*6,26,15,856*	(*d*) 4,707,959
Average . . .	*307,362,401*	*1,234,387*	*5,78,73,193*	*4,319,280*

(*a*) The metric ton is assumed to be equivalent to 249 Imperial gallons of crude petroleum, of an average specific gravity of about 0·885.

(*b*) £1=Rs. 13·4. (*c*) £1=Rs. 13·5. (*d*) £1=Rs. 13·3.

The world's production of petroleum reached its peak in 1929 when it attained a total of over 206 million metric tons. For the four following years, mainly because of restricted production in the United States of America, the total production declined steadily. In 1930, it was 195 million metric tons; in 1931, 190 million metric tons; and in 1932, 181 million metric tons. In 1933 there was a general increase in production, the estimated total for the year being 198 million metric tons. The figures quoted are from the annual statistics published by the Institution of Petroleum Technologists, London.[1]

The world's production.

India contributes only a very small proportion of the world's marketed supply. In 1929, India stood 11th on the list of petroleum-producing countries of the world, but in 1930 she was overtaken by Trinidad and remained 12th for the remainder of the period, her contribution to the world total being only 0·6 per cent. The three major contributors continued to be the U. S. A., Russia and Venezuela. In 1928, the U. S. A. were producing 67·3 per cent. of the world's total. Because of restriction this steadily declined to 59·4 per cent. in 1932, but is estimated to have increased to 62·1 per cent. in 1933. In 1928, Russia stood 3rd on the list with 6·3 per cent. of the total, but her percentage contribution increased to a peak of 11·9 per cent. in 1931 when she displaced Venezuela in second place. Venezuela was producing 8·6 per cent. of the world total in 1928 and rose to 10·4 per cent. in 1930. In 1933 her contribution was estimated to be 9·0 per cent. The estimated percentage totals for 1933 of the other major petroleum-producing countries on the list are: Rumania, 3·7 per cent.; Persia, 3·7 per cent.; Mexico, 2·6 per cent.; Dutch East Indies, 2·6 per cent.; Argentina, 1·0 per cent.; Columbia, 0·9 per cent.; Peru, 0·9 per cent.; and Trinidad, 0·7 per cent. Iraq at present stands 20th on the list with a contribution of 0·008 per cent. Because of her large reserves and the completion of the pipe-line to the Mediterranean seaboard, a large increase in her production during the next quinquennium may be anticipated. Persia, also, has very large reserves and should ultimately prove more important than Rumania.

Despite the existing economic depression, the consumption of petroleum and its products is still on the increase in India and Burma

[1] George Sell, *Journ. Inst. Pet. Tech.*, 19, p. 673, (1933); 20, p. 651, (1934).

Import duties.

and there persists a large market for foreign oil, which has to pay an import duty. A statement showing the rates of import duty on mineral oils during the years 1929 to 1933 is given in Table 91.

Imports.

The average annual imports of foreign mineral oil into India during the financial years during the preceding quinquennium amounted to 194,518,757 gallons, valued at Rs. 9,42,61,445. During the period under review the corresponding figures were 228,315,287 gallons valued at Rs. 9,59,25,704. A peak was reached in the financial year 1929-30 when the imports amounted to 252,767,774 gallons valued at Rs. 11,04,04,035 and steadily declined to 187,783,731 gallons valued at Rs. 6,69,80,093 in the financial year 1932-33. As in the previous quinquennium, Persia stood first in the list and increased her percentage of the total from an average of 38·2 per cent. to an average of 41·7 per cent. While still maintaining second place, the U. S. A. fell sharply from an average of 34·8 per cent. of the total, to an average of 15·7 per cent.; her decline was particularly marked in the year 1932-33, when her contribution was only 8·9 per cent. of the total. Borneo has maintained her position and the U. S. A. deficit has been made good by other countries, notably Georgia and Rumania. The origin of foreign oil imported into India during the years 1928-29 to 1932-33 is given in Table 92.

Value of imports.

The values of the imported mineral oil in the period under review are shown in Table 93; the average annual value was Rs. 9,59,25,704 as compared with the average of Rs. 9,42,61,445 for the previous period. Despite the very large decrease in the volume of oil imported from the U. S. A., this country still maintained its lead in the value of the oil imported. The average value per gallon of all oil imported during the quinquennium was As. 6·72 as compared with As. 7·75 in the preceding period.

Exports.

Despite the fact that the production of petroleum attained record proportions during the quinquennium, the annual exports of mineral oil continued to decline rapidly and have now reached negligible proportions. The average annual exports of mineral oil for the period amounted to only 89,401 gallons as compared with 7,568,961 gallons for the preceding quinquennium. On the other hand the average annual exports of paraffin wax increased to 1,102,692 cwt. as compared with 795,596 cwt. in

TABLE 91.—*Statement showing the rates of Import duty on Mineral Oils during the years 1929 to 1933.*

Serial No. in the Indian Custom Tariff (10th issue).	Names of articles.	Import duty as in force on and from							REMARKS.
		1st January 1929.	28th February 1929.	1st March 1930.	1st March 1931.	30th September 1931.	1st January 1933.	23rd December 1933.	
38A	Kerosene : also any mineral oil other than kerosene and motor spirit which has its flashing point below one hundred degrees of Fahrenheit's thermometer, by Abel's close test.	Re. 0-2-6 per Imp. gallon.	..	Re. 0-2-3 per Imp. gallon.	Re. 0-3-0 per Imp. gallon.	Re. 0-3-9 per Imp. gallon.	..	..	
38B	Motor Spirit	Re. 0-4-0 per Imp. gallon.	Re. 0-6-0 per Imp. gallon.	..	Re. 0-8-0 per Imp. gallon.	Re. 0-10-0 per Imp. gallon.	..	..	
38BB	Mineral Oil, not included in Serial No. 38A or Serial No. 38B, which is suitable for use as an illuminant in wick lamps.	15 per cent. *ad valorem.*	..	..	20 per cent. *ad valorem.*	25 per cent. *ad valorem.*	..	Re. 0-3-9 per Imp. gallon.	
38C	Mineral Oil— (1) which has its flashing point at or above two hundred degrees of Fahrenheit's thermometer, and is ordinarily used for the batching of jute or other fibre ;	Rs. 10 per ton.	..	..	Rs. 12-8 per ton.	Rs. 15-10 per ton.	..	..	
	(2) which has its flashing point at or above one hundred and fifty degrees of Fahrenheit's thermometer, (is not suitable for use as an illuminant in wick lamps)* and is such as is not ordinarily used except as fuel or for some sanitary or hygienic purposes.	7½ per cent. *ad valorem.*	..	..	10 per cent. *ad valorem.*	12½ per cent. *ad valorem.*	..	..	* The words in brackets have been inserted with effect from 23rd December 1933.
38D	Lubricating oil, that is oil such as is not ordinarily used for any other purpose than lubrication, excluding any mineral oil which has its flashing point below two hundred degrees of the Fahrenheit thermometer by Abel's close test.	Re. 0-1-4 per Imp. gallon.	..	..	Re. 0-1-8 per Imp. gallon.	Re. 0-2-1 per Imp. gallon.	Re. 0-2-6 per Imp. gallon (Standard) and Re. 0-0-6 per Imp. gallon (U. K. preferential).	..	
40	All sorts of animal or mineral oils not otherwise specified.	15 per cent. *ad valorem.*	..	..	20 per cent. *ad valorem*	25 per cent. *ad valorem.*	..	..	

TABLE 92.—*Origin of foreign Mineral Oil imported into India during years 1928-29 to 1932-33.*

Countries.	1928-29		1929-30		1930-31		1931-32		1932-33		Average.	
	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*
Borneo	36,294,251	*15·0*	32,800,187	*13·0*	29,330,374	*12·1*	32,413,363	*15·0*	29,329,738	*15·6*	32,043,582	*14·1*
Georgia	27,495,456	*11·3*	20,736,624	*8·2*	22,049,237	*9·1*	24,020,825	*11·1*	28,347,403	*15·1*	24,529,909	*11·0*
Persia	113,843,925	*47·1*	110,148,812	*43·6*	94,170,473	*38·8*	88,131,449	*40·7*	72,342,325	*38·5*	95,739,197	*41·7*
United States of America.	31,417,900	*13·0*	40,800,189	*16·1*	48,985,147	*20·2*	43,488,938	*20·1*	16,719,315	*8·9*	36,282,310	*15·7*
Other Countries	32,852,909	*13·6*	48,281,962	*19·1*	47,895,213	*19·8*	28,526,410	*13·1*	41,044,950	*21·9*	39,720,389	*17·5*
TOTAL	**241,904,501**	*100·0*	**252,767,774**	*100·0*	**242,489,444**	*100·0*	**216,630,985**	*100·0*	**187,783,731**	*100·0*	**228,315,287**	*100·0*
Value	Rs. *10,70,29 950*		Rs. *11,04,04,035*		Rs. *10,48,19,554*		Rs. *9,03,94,890*		Rs. *6,69,80,093*		Rs. *9,59,25,704*	

TABLE 93.—*Annual value of Mineral Oil imported during the years 1928-29 to 1932-33.*

Countries.	1928-29	1929-30	1930-31	1931-32	1932-33	Average.	*Average value per gallon.*
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	*As.*
Borneo	1,38,25,079	1,20,22,812	81,77,768	91,49,950	69,03,236	1,00,15,769	*5·00*
Georgia	1,50,39,846	1,06,99,260	1,21,35,621	1,12,85,874	1,04,37,025	1,19,19,525	*7·77*
Persia	3,17,64,178	3,10,29,146	2,30,41,208	2,36,56,547	1,67,34,744	2,52,45,165	*4·22*
United States of America	2,62,39,561	3,12,06,974	3,67,93,669	3,15,64,413	1,31,11,190	2,77,83,161	*12·25*
Other countries	2,01,61,286	2,54,45,843	2,46,71,288	1,47,38,106	1,97,93,898	2,09,62,084	*8·44*
Total	10,70,29,950	11,04,04,035	10,48,19,554	9,03,94,890	6,69,80,093	9,59,25,704	*6·72*

the preceding period. The exports of mineral oil and paraffin wax during the years 1929 to 1933 are shown in Table 94.

TABLE 94.—*Exports of Mineral Oil and Paraffin Wax during the years 1929 to 1933.*

Years.	Mineral Oil.	Paraffin Wax.
	Gallons.	Cwt.
1929	113,038	1,280,120
1930	77,355	1,223,880
1931	68,935	1,032,040
1932	114,102	942,160
1933	73,575	1,035,260
Average	*89,401*	*1,102,692*

Occurrence of Indian petroleum.

The known petroleum resources of the Indian Empire are confined to the sites of three ancient gulfs[1] :—

(1) The Burmese gulf, covering what is now the basin of the lower Irrawaddy and its main tributary the Chindwin and opening southward into the Bay of Bengal.

(2) The Assam gulf, occupying the middle portion of the present Brahmaputra and debouching into the Bay of Bengal *viâ* the modern Meghna basin ; and

(3) The Punjab—Baluchistan gulf, extending along the base of the Himalaya northwestward from a point, opposite Naini Tal and curving round through the Potwar plateau south-south-westward through what are now the Baluchistan hill ranges to the Arabian Sea.

In all three areas the oil is associated with Tertiary strata. In Burma it is known to occur in beds of Nummulitic age, but by far the greater number of seepages and all the fields of importance are in the next highest geological series, to which there is every reason

[1] E. H. Pascoe, *Rec. Geol. Surv. Ind.*, LXIV, pp. 263-264, (1930).

to suppose the oil is indigenous. In Assam, oil is found in a similar series. In the Punjab, on the other hand, it is the Nummulitic which is the predominant oil-yielding series and, although the only supplies which have so far proved of economic importance are found in the series above, there is good reason to suppose that the oil has migrated up from the Nummulitic below.

The provincial production of petroleum in India is shown in Table 95.

TABLE 95.—*Provincial production of Petroleum during the years 1929 to 1933.*

Provinces.	1929.	1930.	1931.	1932.	1933.
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.
Burma . .	253,400,524	256,554,027	243,914,568	247,570,295	249,000,899
Assam . .	33,538,689	46,813,881	55,546,463	55,135,256	52,771,987
Punjab . .	19,208,880	7,662,200	5,557,720	5,900,480	4,236,136
Total gallons .	**306,148,093**	**311,030,108**	**305,018,751**	**308,606,031**	**306,009,022**
Total metric tons	*1,229,510*	*1,249,117*	*1,224,975*	*1,239,382*	*1,228,952*

Burma.

The most productive oilfields of Burma form a belt along the Chindwin-Irrawaddy valley and include the oilfields of the Upper Chindwin, Yenangyat in the Pakokku district, Singu in Myingyan, Yenangyaung in Magwe, and the Minbu and Thayetmyo fields. G. W. Lepper[1] has pointed out that a striking feature of the geological structure of the Chindwin-Irrawaddy valley is the long synclinal trough which separates the western monocline from a broad series of folds to the east. The main oilfields of Burma are on the first anticlines which rise to the east of this syncline, and on its western margin are numerous oil-shows in the western outcrops. Oil seepages are rare to the east of the folds forming the eastern boundary of the main syncline; test wells on structures which do not arise directly from this syncline have found little or no oil. Lepper concludes that most

[1] *Proc. World Pet. Cong.*, I, pp. 15-25, (1933).

of the oil in the main fields of Burma originated in the marine sediments of the median syncline, which probably marks the site of an extensive depression in the general area of deposition. He remarks that the essential condition for the occurrence of oilfields in Burma seems to be the formation and preservation of closed structures on the margin of this depression. If such structures had been developed immediately to the west, as well as to the east, of the main synclinal depression, Burma would have been the richer by many more oilfields. The production of the Burma oilfields for the years 1929-1933 is shown in Table 96.

TABLE 96.—*Production of the Burma Oilfields during the years 1929 to 1933.*

Oilfield or District.	1929	1930	1931	1932	1933	*Average.*
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.
Akyab . .	1,980	..	..	..	..	*396*
Kyaukpyu .	15,034	14,616	13,068	13,237	14,350	*14,061*
Minbu . .	5,815,252	5,038,476	3,998,633	3,850,716	3,718,250	*4,483,265*
Singu . .	91,481,726	95,368,470	85,478,378	88,941,939	82,613,112	*88,776,725*
Thayetmyo .	746,221	503,811	577,840	464,326	434,572	*545,354*
Upper Chindwin	2,796,560	2,858,096	2,777,102	4 040,690	3,052,778	*3,105,645*
Yenangyat .	17,606,935	19,877,276	19,809,104	23,067,644	23,481,982	*20,763,588*
Yenangyaung .	134,936,816	132,893,282	131,265,443	127,191,743	135,685,855	*132,394,628*
Total gallons .	**253,400,524**	**256,554,027**	**243,914,568**	**247,570,295**	**249,000,899**	*250,088,062*
Total metric tons	*1,017,673*	*1,030,337*	*979,577*	*994,258*	*1,000,004*	*1,004,370*

Yenangyaung.

The Yenangyaung field maintained its reputation of being one of the most wonderful oilfields in the world. Despite expectations to the contrary it easily maintained its lead as a producer throughout the quinquennial period. The field is chiefly remarkable for its long life and the high concentration of oil per acre. Its prolific nature is probably due to its position in the centre of a wide gathering ground whence the oil may have become concentrated by lateral migration. In structure the field is a gentle, elongated dome. The crest maximum is attained in Khodaung, to the south of which there is a saddle followed by a change in pitch which gives rise to a minor domal area in Beme. The fold is slightly asymmetric with the gentler dip on the eastern side.

The importance of the asymmetry of the field lies in the eastward displacement of the productive limits of the deeper sands. The development of the eastern flank has proceeded steadily during the quinquennial period and is responsible for the bulk of the new production. At the close of the period the productive limits had not yet been reached and a very large potentially productive area had been proved, so that ample supplies of oil are assured for some years to come. Within the Reserves flush production was obtained from deep sands in the eastern part of the Twingon Reserve and in the south-eastern part of the Beme Reserve. The search for new deep horizons continued, but so far, owing to drilling difficulties, has been unsuccessful.

Despite the congestion in the Reserve, it is probable that Yenangyaung is one of the most efficiently operated fields in the world. There are certainly few in which greater precautions are taken to prevent damage to the sands by flooding or from other causes. This has been made possible by co-operation between the several operating companies whose field superintendents and representatives of their geological staffs, together with a member of the Geological Survey of India, constitute an Advisory Board which advises the Warden upon technical matters pertaining to the development of the field.

Singu.

From the point of view of production the Singu field ranks second in Burma and constitutes the principal reserve supply of petroleum in the province. The greater part of the field is worked by the Burmah Oil Company, which draws upon it for only such supplies of crude oil as are necessary to stabilise the through-put of its refinery at Syrian. For this reason the production figures do not adequately indicate the potential capabilities of the field.

The Singu field is situated at the southern end of the uplift on which the Yenangyat and Sabe fields also lie, the total length of the fold being a little less than 39 miles. The axis at Singu is slightly west of that at Yenangyat. At the southern end of the fold the crest rises rapidly; in the square mile block north of this the pitch is about 6° ; further north the rise is more rapid until the maximum is reached about $\frac{3}{8}$ mile to the north. The crest maximum is maintained for about one mile and there is then a gentle northerly pitch as far as the River Irrawaddy. The fold is sharply asymmetric and on the eastern flank the average thickness of the Pegu

strata is only about 1,450 feet as compared with 3,000 feet on the western limb.

When compared with conditions at Yenangyaung, Singu is characterised by the regularity of its producing horizons and the equality in yield from wells producing from these sands at similar positions on the structure. The richest parts of the field are found in the neighbourhood of the crest maximum, where the first producing zone occurs at a depth of from 1,400 to 1,450 feet. Another producing zone occurs at a depth of from 1,800 to 1,900 feet near the top of the structure, while many wells are producing from the 3,000 foot zone the margin of which has been found to lie within that of the shallower sands in the southern part of the field, but outside it in the northern.

During the quinquennial period a deep test well was sunk in block 57 N to a depth of about 6,000 feet but without proving new productive horizons. Test wells at Ainggyi, south of the main structure, were also unsuccessful. At the close of the period active competitive drilling was in progress to a productive zone found at a depth of about 4,500 feet along the line between blocks 50N and 50E; on the other hand competitive drilling on the line between blocks 57N and 58N ceased because of the transfer of the Hessford Development Syndicate's interests to the Burmah Oil Company. At the close of the period the Burmah Oil Company were actively engaged upon the construction of a wall, similar to that built by the Indo-Burma Petroleum Company at Lanywa, designed to reclaim a potentially productive area in the bed of the Irrawaddy.

Lanywa.

The Lanywa field is a structural continuation of the Singu field, being cut off from it by the river Irrawaddy. The productive area lies in an embayment of the river behind the Lanywa-Sitpin sandbank. The area has now been successfully reclaimed behind the massive revetted embankment constructed by the Indo-Burma Petroleum Company. Over 50 wells have been drilled in the reclaimed land and the field has been developed successfully in accordance with the best and most up-to-date practice.

Yenangyat.

The small Yenangyat and Sabe fields are situated on a highly asymmetric and faulted anticline whose axis is slightly east of that at Singu and Lanywa. Though the structure is favourably situated, denudation has removed much of the petroliferous Pegu strata and only the lower of the

Singu horizons are found at Yenangyat so that the potential production is small as compared with that at Singu. The field reached its peak in 1903, the wells being characterised by high initial productions and rapid declines. From that date production has declined steadily, but recent developments justify the expectation that the present decline may be arrested.

Upper Chindwin.

The Indaw field is the most northerly and the most recently discovered of the Burmese fields. Though production dates from 1918 development of the field has been slow on account of drilling difficulties and the remote and inaccessible nature of the area. The average production during the quinquennial period was 3,105,045 gallons, with a maximum of 4,040,690 gallons in 1932, as compared with an average of 1,162,627 gallons for the years 1924 to 1928, with a maximum of 2,308,880 gallons in 1928. The crude oil produced at Indaw by the Indo-Burma Petroleum Company is sent by pipe-line to Pantha, on the river Chindwin, where it is refined. A thorough exploration for oil has been carried out in other parts of the Upper Chindwin district, but as yet no new commercial deposits have been proved.

Minbu.

The Minbu, Palanyon and Yethaya fields are on a single asymmetric anticline of the Yenangyat-Singu type. The eastern limb of the fold is usually over-thrust. The compression of the structure is partly responsible for the narrowness of the productive area and the limitation of the oil accumulations. Other causes are the erosion of the higher potentially petroliferous horizons and the unsuitable lithology of the deeper beds. Much of the oil produced is of a heavy type less profitable to refine than that produced from other fields in Burma. Production began in 1910; decline set in 1919 but was arrested by shallow drilling in the Shwelinban (Minbu Town) area where the limit of economic spacing was reached in 1929. A deep test well in the Yethaya portion of the structure was drilled to a depth of about 5,000 feet but was abandoned in 1931 without obtaining commercial production, though shows of oil and high pressure gas sands were encountered. A deep test at Palanyon was more successful and encountered gas and a crude oil of greater value than is usual at Minbu. The production from the Minbu field has never been large and a continuation of the present decline may be expected.

For many years a good deal of exploratory drilling has been carried out in the Thayetmyo district, but without the proving of

Thayetmyo.

any large accumulations of petroleum. There are small producing fields at Padaukpin and at Yenanma but their production is unimportant. Exploratory drilling has been continued at Minhla, but so far without important results. The Burmah Oil Company are drilling a deep test well at Monatkon to test an anticline immediately east of the syncline, bordering the western outcrops.

Akyab and Kyaukpyu.

Though the Akyab region belongs to the Assam gulf, it is geographically situated in Burma. A great deal of exploratory work has been carried out in the past, both by geological reconnaissance and by testing with the drill, without the discovery of any really important accumulations. There are many seepages of oil and gas both on the mainland and on islands off the Arakan coast and for many years a small indigenous industry has existed. Folding and denudation in these regions has been too severe to warrant the expectation of oil in much quantity. During the quinquennial period the small output from Kyaukpyu has continued to decline while that from Akyab has ceased since 1929.

Assam.

The most important accumulations of petroleum in Assam are concentrated in three regions: in the Lakhimpur district in Upper Assam; in the Surma Valley in Cachar; and in the Arakan Islands. The important Digboi field is in the first of these regions. The structure is a steeply folded asymmetric dome with a steep pitch to the west and a gentle pitch to the east. Systematic drilling has been conducted at Digboi since 1888 and the expectation of increased production foreseen in the last quinquennial report has been fulfilled. A summary of the output of the Digboi refineries in the years 1929 to 1933 is given in Table 97.

TABLE 97.—*Output of the Digboi oil refineries in the years 1929 to 1933, (in gallons).*

	1929	1930	1931	1932	1933
Kerosene	12,023,798	15,790,315	23,694,654	24,077,488	23,196,736
Batching and lubricating oil .	290,254	347,027	172,446	178,072	186,522
Spirit	7,232,127	9,033,315	12,319,230	12,927,284	12,995,295
Wax	3,301,213	4,016,409	4,871,553	3,491,792	1,590,442
Sundry oils	2,979,792	4,402,747	3,445,033	2,303,331	5,646,849

In the Surma Valley area, the small Badarpur field in Cachar has been consistently disappointing since it was first developed some twenty years ago. The structure is a small and asymmetric dome. The crude oil is of inferior quantity and is accompanied by much salt water; the wells are characterised by rapid decline curves; and the drilling difficulties are unusually great. Since the natural decline of the oilsands could no longer be offset by drilling and reconditioning, the Badarpur field was finally abandoned during 1933. Exploratory drilling was continued in the Patharia area, but the test well was temporarily shut down at the close of the period. The testing of the Masimpur anticline near the head of the Surma Valley in the Cachar district has been continued with the greatest vigour but, unfortunately, so far without decisive results. It is probable that this area presents a combination of drilling problems unequalled anywhere else in the world. The occurrences of oil at Kyaukpyu and on the Arakan coast have been included in the paragraphs relating to Burma.

Punjab-Baluchistan.

In the Punjab and Baluchistan there are numerous indications of the presence of petroleum but often either the structure is so compressed as to prevent the accumulation of large deposits, or the petroliferous horizons have been deeply eroded. Several promising structures have been carefully tested, but the Khaur field remains the only source of commercial production. In structure the Khaur field is an elongated, slightly asymmetric dome. The maximum dip on the flanks is about 45° while the gentle pitch attains an angle of about 7°. The structure is exceptionally regular and correlation of the various producing horizons is simple. The oil is thought to have originated in Eocene rocks and to have migrated upwards into the younger Murree beds above. The Khaur field was first developed in 1915 but production was small until 1922. In that year the Attock Oil Company's refinery was opened at Rawalpindi and production rose to over 7½ million gallons. A peak production of over 19 million gallons was reached in 1929 but fell in the following year to 7⅝ million gallons. Since then production has declined steadily and in 1933 was a little less than 4¼ million gallons. Because of the very high pressures encountered at depth, drilling in search of deeper productive horizons is a matter of considerable technical difficulty. In 1933 a deep test well was successfully drilled to a depth of 5,887 feet. Small quantities of oil were found in the lime-

stone which was encountered at a depth of 5,600 feet while there were indications of gas and oil in the strata immediately overlying the limestone. Another well is being deepened to test the value of these indications.

Ruby, Sapphire and Spinel.

[A. M. HERON.]

Production.

With the exception of the sapphires from Kashmir, the whole of the Indian Empire's production of rubies, sapphires and spinels for the period under review was obtained from the Mogok Stone Tract of Upper Burma. The stones are won both by the Burma Ruby Mines Limited, which went into liquidation in 1925, and ceased work in 1931, and by a large number of indigenous workers who exploit various types of gem-bearing ground by primitive methods. No records are kept of the output of the latter industry and the statistics which have been given in earlier reviews, as well as those quoted herein, refer only to the production of the Company. Table 98 shows these annual output figures for the period 1929-33, the average annual value being only £7,538 as compared with £26,228 for the previous quinquennium. For 1932 no returns were available and in 1933 the only return was of 1,103 carats of rubies from Kathe.

TABLE 98.—*Quantity and value of Ruby, Sapphire and Spinel produced in Burma during the years 1929 to 1933.*

Year.	Quantity.	Value.	
	Carats.	*Rs.*	£
1929	44,650 (e)	*3,31,760*	24,758(a)
1930	30,090	*1,31,155*	9,715(b)
1931	(c)	*42,864*	3,175(b)
1932	..	..	..
1933	1,103	*583*	44(d)
Average	*15,169*	*1,01,272*	*7,538*

(a) £1=Rs. 13·4 (b) £1=Rs. 13·5 (c) Not available. (d) £1=Rs. 13·3.
(e) Includes 1000 carats of sapphires found by a native licensee.

In 1929 a sapphire of about 1000 carats and in 1930 a fine sapphire of 630 carats, a star sapphire of 293 carats and a ruby of 100 carats were found; the two sapphires of 1930 were found at Kathe; in 1932 a fine ruby of 17 carats was found at Chaunggyi, a fine sapphire of 90 carats and a good star sapphire of 453 carats at Kathe.

The Burmese industry.

A race of hereditary gem miners exists in Mogok, and the methods of the old Burmese administration, modified in accordance with the principles of equity, form the foundation of the Upper Burma Ruby Regulation under which their activities are carried on. The interests of the native miner were fully safeguarded when a lease was given to the Burma Ruby Mines Ltd. Licenses to win gems are granted to descendants of the old families and land is allotted to them as occasion arises. The royalty received by the Local Government on account of license fees for the winning of rubies, sapphires, spinels, etc., is the only index we possess of the condition of the indigenous industry. Table 99 shows that an average annual royalty of Rs. 1,68,971 was received for the period under review, as against Rs. 1,20,490 for the previous quinquennium.

TABLE 99.—*Royalty or license fee collected in Burma on Rubies, Sapphires and other Precious Stones.*

Year.	Amount.
	Rs.
1929	3,10,140
1930	2,34,740
1931	92,770
1932	87,461
1933	1,19,744
Average	*1,68,971*

The royalty collected in 1928 was Rs. 2,20,280, more than double that of any of the years 1924-1927, but the prosperity shown by the years 1928-1930 has not been maintained.

It is not generally realised that in addition to rubies, sapphires and spinels, gems which in their better classes are of incomparable beauty and as far as rubies and spinels are concerned, easily the finest specimens found anywhere in the world, Burma produces a further wide range of precious and semi-precious stones amongst which gem varieties of the following minerals are of frequent occurrence :—

Quartz (amethyst, etc.), apatite, beryl (aquamarine), chrysoberyl, epidote, garnet, iolite (water sapphire), lapis lazuli, felspar (moonstone), olivine (peridot), phenakite, tourmaline (rubellite), topaz, zircon (hyacinth).

Burma history.

The original Mogok Stone Tract was annexed by the ruling Burmese monarch in 1597, but precious stones had probably been obtained therein for long periods before that date. This is not the place to trace the history of the tract in detail and it must suffice to state that Mogok was occupied by the British in 1886. In October, 1887, the Upper Burma Ruby Regulations (XII of 1887), a regulation to declare the law relating to rubies and other precious stones, came into force and by it the Local Government were empowered to notify the 'stone tracts' and to make rules regarding the mining, cutting, possession, buying, selling and carrying of precious stones and to grant licenses for these purposes. In November, 1887, the Mogok Stone Tract was constituted. It is contained within the boundaries of the existing Mogok township, which enclosed the older Burmese townships of Mogok, Kyatpyin and Kathe.

The first lease of the Burma Ruby Mines Limited, was granted in 1889, a second one came into operation in 1897, and a third one for a period of 25 years in 1904. It was about 1907 that the market for gem stones became depressed and subsequent events were ably summarised in the Quinquennial Review for 1909-1913. It is only necessary to add here that in 1925 the company went into voluntary liquidation and such stones as have been won since that date, are due in part to its letting out certain gem-bearing areas on a modified tribute system. The regrettable demise of this famous concern after its chequered career of 36 years is best quoted in the words of the 'Note on the Mineral Production of Burma during the year 1925.'

'The Sinkwa mine was closed during the year. The best parts of the Mogok and Kathe valleys are reported to be approaching exhaustion and the residue of ruby-bearing ground in these areas is said to be insufficiently rich to pay for extensive working. These mines are now let out to tributors who clean up patches of ruby-earth left in crevices and detached spots. The loss on last year's working has finally exhausted the capital of the company which has since decided to go into voluntary liquidation.'

In the opinion of Dr. J. Coggin Brown, who has devoted some time to the study of the industry, the present condition of gem-mining in Burma is due to the cumulative effect of numerous adverse causes, but exhaustion of the gem-bearing deposits as a whole is not one of them. The Mogok Stone Tract occupies more than 600 square miles, the greater part of which is occupied by gneisses and associated rocks of Archaean age, amongst them being great bands of crystalline limestone from which most of the precious and semi-precious stones, and all the rubies and spinels, have been derived. The weathered products of the limestone have accumulated in the water-borne gravels and it follows of necessity from the existence of gems in such situations, that they occur also in the detrital deposits of the hill slopes, whence the true alluvials are derived. The operations of the Burma Ruby Mines Limited, apart from early abortive attempts to mine gems from solid limestone and a few inconclusive experiments on certain hill slopes, were mainly confined to the removal and treatment of gravel from the Mogok, Kyatpyin and Kathe valleys. There are other valleys in the Stone Tract, in which gems are known to occur, and which deserve fuller exploration than they have hitherto received, with the object of proving their value as hydraulicking propositions, rather than as deposits to be opened up by costly and laborious hand methods.

Rubies and other precious stones are known to occur at other places in Burma and 'stone tracts' have been declared by the Local Government to exist within certain areas in the State of Möngmit and its dependency Mong Long; within the Thabeitkyin township of the Katha district; within the Myitkyina district (the Nanyaseik Stone Tract); within the Mandalay district (the Sagyin Stone Tract) and within the State of Kengtung.

Kashmir.

An output of 5·7 cwts. of sapphire with corundum valued at Rs. 92,000 (£6 917) was reported in 1933 from Udhampur, Kashmir State, (*see* corundum).

Salt.

[E. R. GEE.]

General.

The average annual production of salt in India, excluding Aden, during the five years 1929 to 1933 was 1,452,264 statute tons (*see* Table 100). The corresponding figure for the previous quinquennium was 1,343,587 tons so that there was an average increase in production of 108,677 statute tons per annum, that is, a rise of 8·1 per cent. This increase is distributed in small amounts over all the main producing regions of India. Imports from Aden and foreign countries combined, on the other hand, decreased from an annual average of 580,943 tons in 1924-1928, to 548,788 tons in 1929-1933, a decrease of 32,155 tons a year. The amount of salt produced in the country *plus* that imported by sea has, therefore, risen from 1,924,530 to about 2,001,052 tons per year.

Duty on salt.

The duty on salt is paid into central and not into provincial revenues and is collected by the Central Board of Revenue. The amount of duty levied per maund ($82\frac{2}{7}$ lbs.) during the period 1929-1934 was as follows:—

Period.	Indian salt (including Aden salt).			Foreign salt.		
	Rs.	A.	P.	Rs.	A.	P.
Until 17th March, 1931	1	4	0	1	4	0
18th March, 1931 till 29th September, 1931	1	4	0	1	8	6
30th September, 1931 till 15th November, 1931	1	9	0	1	14	$7\frac{1}{2}$
16th November, 1931 till 29th March, 1933	1	9	0	1	13	6
30th March, 1933 till end of 1934	1	9	0	1	11	6

The effect of this extra import duty on foreign salt (Aden salt being, of course, exempt from this additional tax) will be observed in Table 104 and in Table 105 dealing with imports into Bengal.

Consumption per head.

Using the population figures given in the 1931 census report, a consumption per head of about 12·5 lbs. of salt per annum is indicated. This figure includes salt used in husbandry and industry (chiefly fish-curing) so the amount consumed per inhabitant is some-

what less. The figure arrived at is, however, about one pound per head less than the average for the previous quinquennium. This apparent fall in the rate of consumption is doubtless largely explained by the increased population figures given by the 1931 census. Actually, in many of the backward tracts of the interior, the consumption figure is probably much below this average, for we find that in the case of certain provinces of which separate statistics are available, the rates are appreciably higher than 12·5 lbs. per capita.

TABLE 100.—*Production of Salt in India (excluding Aden).*

Year.	Statute Tons.	Metric Tons.
1929	1,488,417	1,512,232
1930	1,363,854	1,385,676
1931	1,588,017	1,613,425
1932	1,365,602	1,387,451
1933	1,455,432	1,478,719
Average	*1,452,264*	*1,475,600*
Annual average for 1924-28	*1,343,587*	*1,365,084*

Sources of Indian salt.

The salt produced in India is obtained from three principal sources, (*a*) sea water, (*b*) lakes and subsoil water in areas where the rivers have no outlet to the sea, and (*c*) rock-salt beds. Omitting the Aden production, about two-thirds of the salt made in India is recovered from sea water, chiefly in Bombay and Madras; about one-eighth is mined or quarried as rock-salt, chiefly in the Punjab Salt Range; and the rest, about one-fifth, comes from areas of internal drainage, the Sambhar lake in Rajputana being the largest producer in this class.

TABLE 101.—*Provincial production of Salt.*

Province.	1929	1930	1931	1932	1933	Average	Percentage variation compared with 1924-28.
	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	
Aden . . .	246,243	207,852	286,037	291,241	308,129	*267,800*	+38·5
Bengal . .	..	..	..	..	13	*3*	..
Bombay and Sind	535,445	545,327	523,706	451,396	466,702	*504,515*	+10·3
Burma . .	23,825	19,223	22,974	25,084	35,789	*25,379*	+16·3
Gwalior (*a*) . .	21	25	48	43	35	*34*	..
Madras . .	421,208	341,756	555,440	446,556	490,510	*451,096*	+1·7
Northern India .	507,918	457,523	485,840	442,523	462,383	*471,237*	+12·0
Total .	1,734,660	1,571,206	1,874,054	1,656,843	1,763,561	*1,720,064*	+11·9

(*a*) Figures relate to official years.

Brief accounts of the general methods of production in the various areas will be found in the Quinquennial Review of Mineral Production of India for 1924-28.[1]

Aden salt.

Reviewing the figures for the various producing regions, it is observed that the output of Aden salt first declined from about 246,000 tons in 1929, to about 207,000 tons in 1930, after which it rose to approximately 300,000 tons per annum. This increase was undoubtedly due principally to the additional tax that was imposed on foreign salt from March, 1931, and it has resulted in an average production of more than 38 per cent. in excess of the figure for the previous quinquennium. In the case of the other three principal producing areas, a slight increase is shown in the figures for Madras, whilst the outputs of Northern India and Bombay and Sind increased by about 12 per cent. and 10 per cent. respectively.

Bombay salt.

As in the case of Aden, most of the Bombay production is by the direct solar evaporation of sea water. The factories at Dharasna and Chharvada on the eastern side of the Gulf of Cambay near Bulsar are both Government property and are worked under departmental control. The

[1] *Rec. Geol. Surv. Ind.*, LXIV, pp. 276-287, (1930); *see* also W. A. K. Christie, *Capital*, **Indian Industries, Trade and Transport Supplement, 19th December, 1929, p. 37.**

other sea salt works, with three exceptions, are grouped within a radius of 30 miles of Bombay City; some are Government property leased to private concerns, others are owned and worked privately. An appreciable proportion of the Bombay salt is Baragra or Rann salt, made from brine wells on the Little Rann of Cutch. The works are situated at Kharagoda and at Udu (jointly named the Pritchard Salt Works), they are owned by Government and worked departmentally. Since 1923-24, Dhrangadhra State has been permitted to make this kind of salt at Kuda.

The average annual production of salt from the above-mentioned works in Bombay Presidency (excluding Aden and Sind) during the period 1928-29 to 1932-33 was about 464,000 tons. Of this total, about one-fifth was Baragra salt, though in 1932 over one quarter of the total output was derived from this source; the remainder was 'sea-salt'. An increase in the production of Baragra salt to a total of about 116,000 tons occurred in 1929-30 in order to compensate for a shortage of Sambhar (Rajputana) salt. The output of sea-salt also reached the high figure of about 395,500 tons during that period. Trade was somewhat affected in early 1930 by the Civil Disobedience Movement, up-country traders being induced to believe, wrongly, that the duty on salt would be removed or at least reduced. They, therefore, refrained from stocking the usual large supplies for the monsoon season. This lack of local demand was, however, compensated by the issues despatched to certain places normally supplied by Sambhar salt. About three-quarters of the total production of the Baragra salt and of sea-salt is removed for sale outside the Presidency—within the Central Provinces and Deccan areas.

In addition to the above-mentioned production, a small proportion of the salt issued from Bombay is first imported from Portuguese territory—around Goa. In 1930-31, this amounted to about 2·3 per cent. of the total issues of the Bombay Presidency (excluding Aden and Sind) but later, after the imposition of the import duty on foreign salt, the proportion fell to about 1·6 per cent.

Production in Sind.

In the vicinity of Karachi, the salt production of Sind expanded rapidly during the quinquennium under review. Almost all the salt is obtained by solar evaporation from sea-brine, mainly at the Maurypur Salt works. These Government Salt works are now leased to various companies. In addition, salt is obtained from the natural crystallised brine

deposits of Darwari and Saran in the Thar-Parkar district of Sind. The total production of Sind rose from about 36,350 tons in 1929-30 to almost 50,000 tons in 1932-33. This was no doubt largely due to the imposition of the extra duty on foreign salt, about 34,750 tons of salt being shipped from Karachi to Bengal in 1932-33 as compared with 17,350 tons in 1929-30 (*see* Table 105). Dr. J. A. Dunn[1] considers that the area around Karachi is capable of an output up to 200,000 tons per annum.

Madras salt.

In the Madras Presidency, all the salt is made from sea-water and, mainly, in much the same way as in Bombay.[2] A description of the process of manufacture is also given by Mr. V. S. Swaminathan.[3] In 1929-30, however, an experimental scheme of obtaining brine from pits sunk in the coastal alluvium was inaugurated at the Ennore factories. The results were reasonably promising; the experiments were discontinued from 1933 as the possibility of working with pit brine had, it was considered, been sufficiently well demonstrated to the licensees.

Unfavourable weather in 1930 resulted in a relatively poor yield in the Madras Presidency, but in the following year a record output of 555,449 tons was produced. In spite of a lack of issues to Ceylon in the early part of the quinquennium owing to an enhanced import duty into that country, and a decrease in the amount of salt sent to Travancore—the manufacture of salt in Travancore State having increased considerably—sales were maintained, and were assisted during the latter half of the quinquennium by an increased export trade to Bengal (*see* Table 105). Only a very small percentage of the Madras production is manufactured by Government; over 90 per cent. belongs to licensees.

Burma salt.

A brief description of the methods of manufacture of salt in Burma is given in the Quinquennial Review for 1924-28.[4] Further details may be obtained from the recently published book entitled 'The Mineral Resources of Burma'.[5] Most of the annual production averaging about 25,400 tons (an increase of about 16·3 per cent. on that of the previous quinquennium) is made from sea-water in the districts of

[1] *Rec. Geol. Surv. Ind.*, LVI, p. 385, (1925).
[2] *Rec. Geol. Surv. Ind.*, LIX, p. 280, (1930).
[3] *Trans. Min. Geol. Inst. Ind.*, Vol. XXV, Pt. 2, p. 158, (1930).
[4] *Rec. Geol. Surv. Ind.*, LXIV, p. 281, (1930).
[5] H. L. Chhibber, The Mineral Resources of Burma, p. 211, (London, 1934).

Akyab, Kyaukpyu, Sandoway, Hanthawaddy, Bassein, Myaungmya, Thaton, Amherst, Tavoy and Mergui. In Upper Burma, in the districts of Magwe, Pakokku, Myingyan, Yamethin, Sagaing, Shwebo, Katha, Meiktila, Myitkyina, Upper Chindwin and Lower Chindwin, and in the Hukawng Valley, salt is made in hundreds of small works, either from brine wells or by lixiviating saline soil. The salt is recovered by boiling the solution.[1] Recent references to these brine occurrences are to be found in the General Reports of this Department for the years 1928 to 1931,[2] the process of manufacture and details of production being discussed at some length in the report for 1928. In one or two instances, attempts have recently been made to use paddy husk, as a substitute for wood, as fuel. Of the amount of salt consumed in Burma, only about one-fifth to one-quarter is usually manufactured in the country. The remainder is imported (*see* page 298).

Sub-soil and lake-brine.

The most important of the areas worked for sub-soil and lake brine is the desert region of Rajputana. The whole country is impregnated with salt from the coast of Cutch and Sind north and north-eastwards to the borders of Delhi district and Bahawalpur State. In many areas of internal drainage there are temporary salt-lakes, which are utilised, as at Sambhar and Didwana ; while in other places sub-soil brine is raised, as at Pachbadra. Most of the salt in this region appears to be brought in as fine dust by the strong winds which blow from the south-west and south-south-west during the hot weather. These winds blow across the salt-incrusted Rann of Cutch, and carry away sea-spray and finely-powdered salt in large quantities into the heart of Rajputana, where it becomes fixed when the following monsoon brings rain enough to wash the salt into the small lakes in areas of internal drainage.[3]

Sambhar Lake.

Sambhar, the largest of the Rajputana salt-lakes, covers an area of about 90 square miles at its highest level, but dwindles, generally, to a small central puddle by March or April. It has been shown by careful sampling at regular intervals that the mud forming the bed of the lake contains on an average 5·21 per cent. of sodium chloride down to a

[1] *Rec. Geol. Surv. Ind.*, XXXV, p. 97, (1907).
[2] *Rec. Geol. Surv. Ind.*, LXII, pp. 61-63, (1929) ; LXIII, pp. 49-50, (1930) ; LXV, p. 63, (1931) ; LXVI, pp. 71-72, (1932).
[3] T. H. Holland and W. A. K. Christie, *op. cit.*, XXXVIII, pp. 154-186, (1909).

depth of at least 12 feet, and the amount stored in these higher layers of salt cannot thus be less than fifty million tons. When the lake dries up, brine contained in its clay bed rises to the surface by capillarity and is there evaporated to dryness. By a continuation of this process there is produced each year on the top of the lake bed a layer of salt ready for rapid solution by the monsoon rains.

Against floods Sambhar cannot be protected, but against a scarcity of rain protection is now good. Due chiefly to measures devised by Mr. S. A. Bunting[1], it is now possible, even in a season of scanty rainfall, to collect enough brine for the season's manufacture before the lake recedes too far from the shores. A substantial dam has been built across the lake near the Sambhar end, and into it a reservoir of about five square miles of brine from the main body of the lake can be transferred by powerful pumps at the dam. After concentration in this reservoir, it is transferred to smaller condenser-reservoirs and then to groups of evaporating pans called *kyars*. A large new *kyar* of eight million square feet, built on improved lines, was brought into operation during the previous quinquennium.

Table 102 shows the average annual distribution of Sambhar salt during the five official years 1929-30 to 1933-34 with the corresponding figures for the previous quinquennium. A slight increase in the amount of salt supplied to Bihar and Orissa is observed.

TABLE 102.—*Average annual distribution of Sambhar Salt.*

—	1924-25 to 1928-29.		1929-30 to 1933-34.	
	Quantity.	*Per cent. of total.*	Quantity.	*Per cent. of total.*
	Tons.		Tons.	
United Provinces . . .	191,632	*71·4*	139,044	*67·2*
Rajputana	31,110	*11·6*	27,419	*13·3*
Central India . . .	22,206	*8·3*	17,956	*8·7*
Punjab including Feudatory States and Delhi.	12,324	*4·6*	12,066	*5·9*
Central Provinces . . .	6,257	*2·3*	4,052	*1·9*
Bihar and Orissa . . .	4,794	*1·8*	6,287	*3·0*
Average total .	*268,323*	*100·0*	*206,824*	*100·0*

[1] Inst. Civil Engineers, Selected Engineering Papers, No. 30, (1925).

The distribution figures quoted above cannot, however, be taken as a true indication of production; much obviously depends on the opening and closing balances of the periods under review. In 1924-25, the opening balance was 255,265 tons; whilst the closing balance for the end of the quinquennium 1924-25 to 1928-29 was only 82,368 tons. At the end of the quinquennium 1929-30 to 1933-34, the closing balance was 247,465 tons. Thus, although the average *distribution* figures for the former quinquennium exceeded those of 1929-30 to 1933-34 by over 60,000 tons, the average annual *production* figures denote a slight increase, the average yearly output being about 235,000 tons during 1924-25 to 1928-29 and 240,000 tons during 1929-30 to 1933-34.

Production of Rajputana salt.

Normally, between 80 and 90 per cent. of the Rajputana salt is obtained from the Sambhar lake. In July 1929, however, exceptional floods affected the output considerably and a total production of about 245,000 tons only was obtained in that financial year from the three Rajputana sources, against a normal output of nearly 300,000 tons. During the following year, the Rajputana output increased by nearly 40 per cent. to a total of over 343,000 tons. The latter was a maximum for the quinquennium; of the amount, about 275,000 tons were produced at Sambhar.

Didwana and Pachbadra.

At Didwana, the average annual production during 1929-30 to 1933-34 was only about 14,200 tons. The corresponding figure for Pachbadra was 35,800 tons with a maximum of 55,000 tons in 1929-30, and a rapid decline during 1931-33. On the recommendation of the Salt Survey Committee a topographical survey of the Pachbadra salt basin was carried out and completed in 1932. Prior to its completion, a rough provisional scheme for the expansion of the work at Pachbadra and the crushing of the salt for the supply of Bengal, was submitted to the Government of India.[1] By the end of the quinquennium under review, no decision had apparently been arrived at by Government.

Minor amounts of salt, together with saltpetre, are obtained from saline alluvium at small refineries in Bihar, the United Provinces and the Punjab. At Sultanpur, in the Gurgaon district of the latter

[1] Annual Administration Report of the Northern India Salt Revenue Dept. for the year 1932-33, p. 14, (1933).

province, certain old salt works were reopened in 1932 but the results have apparently not been very satisfactory.

Rock-salt.

The production of rock-salt has increased by 5·6 per cent. Details are shown in Table 103.

TABLE 103.—*Production of Rock-salt during the period 1929-33 compared with the period 1924-28.*

Year.	Salt Range, Punjab.	Kohat, North-West Frontier.	Mandi State.	Total.	*Percentage of total salt production of India (including Aden).*
	Tons.	Tons.	Tons.	Tons.	
1929	155,393	19,625	3,284	178,302	*10·4*
1930	148,306	23,005	4,156	175,467	*10·3*
1931	136,544	21,123	4,226	161,893	*8·8*
1932	148,516	19,972	3,555	172,043	*10·7*
1933	145,647	20,577	3,940	170,164	*9·9*
Average for 1929-33 .	*146,881*	*20,860*	*3,832*	*171,573*	*10·0*
Percentage of average total, 1929-33.	*85·6*	*12·2*	*2·2*	..	..
Average for 1924-28 .	*137,179*	*20,931*	*4,368*	*162,478*	*10·6*
Percentage of average total, 1924-28.	*84·4*	*12·9*	*2·7*	..	..

Mayo mine, Khewra.

A general account of the occurrences of rock-salt in the Punjab and North-West Frontier Province will be found in previous reviews[1] and in a paper by Dr. W. A. K. Christie.[2] The mines of the Salt Range are responsible for by far the largest share of the output. A very good description of the salt mines and the methods of excavation employed has been given by Mr. C. H. Pitt,[3] the General Manager. The Mayo mine at Khewra, much the largest in the Range, is worked in a series

[1] *Rec. Geol. Surv. Ind.*, XXXII, pp. 83-84, (1905); LXIV, pp. 284-285, (1930).
[2] *Op. cit.*, XLIV, pp. 241-264, (1914).
[3] *Trans. Min. Geol. Inst. Ind.*, Vol. XXII, p. 197, (1928).

of alternate chambers and pillars running roughly parallel to the dip of the salt seams, the pillars increasing in thickness from 25 feet at the top to 30 feet at the bottom while the width of the chambers decreases correspondingly from 45 to 40 feet. East of Chamber 36 in the Buggy seam and of Pillar 21-22 in the Pharwala, however, the pillars and chambers are of equal size –50 feet in width. There are now 45 working chambers. Some of the older chambers are very large –700 feet long and over 250 feet high – but the mine shows no signs of instability. Mr. Pitt, in 1928, estimated that, with the present system of working and rate of production, the mine has reserves for at least 50 years 'before removal of the pillars need be commenced'[1]. In 1930, the probable *minimum* reserves, excluding pillar extraction and possible unexplored deposits, were estimated at four million tons.[2] During the last ten years, mechanisation of haulage and excavation has proceeded apace and an electrification scheme has recently been completed. For drilling and cutting, air compressors in the mine are now directly coupled to 300 H. P. motors taking alternating current at 3,000 volts from the power station. Both chain and arc-wall cutters are in use. For other purposes the current is transformed down to 400 volts. Towards the end of the quinquennium under review, the question of installing electric haulage was being taken up.

The main seams of rock-salt in the Mayo mine consist of the Buggy, up to 150 feet thick, at the top of the sequence; the Sujowal up to 80 feet and the Pharwala seams below. Of the Pharwala seams, the Middle Pharwala, about 80 feet thick, has proved of particular value in the south-eastern part of the mine where the chambers have been extended during the past quinquennium, and it has been suggested that attempts should be made to work this seam to the dip. Exploitation has also continued in the north-eastern portion of the mine. Here the Buggy and Sujowal seams dip northwards at steep angles along the line of the Low Level Tunnel, and are being developed from high level inclines. Followed towards the south, the seams become almost horizontal and then dip southwards forming a broad anticline with an easterly pitch. It has also been suggested[3] that this easterly pitch will be an important factor in future development.

[1] *Ibid.* p. 230.
[2] E. R. Gee, unpublished report.
[3] *Ibid.*

During the recent geological survey of this area, the field-evidence indicated that the salt deposits of the Mayo mine are cut off, a short distance to the north of the main workings, by an important thrust-fault running approximately up the Great Bhander *kas* and repeating the Salt Marl beds to the north. Evidence of the trend of this fault has been found, recently, in the most northerly workings of the Buggy seam. Although the workable area is, therefore, probably limited to the north, it is suggested that extension to the east will yield further reserves of good quality salt. Only the area south of the fault was included in the estimate of reserves mentioned on page 293; the latter therefore holds good. It has also been suggested that attempts should be made to prove the Salt Marl deposits to the north of the fault, that is, on the north side of the Great Bhander *kas*.[1] During the quinquennium, attempts by drilling have been made to prove the salt deposits of the north slopes of the Makrach gorge. These attempts are not regarded as satisfactory as the borings were carried out at an insufficient distance from the outcrop and the depths of the holes were very limited.

Warcha, Salt Range.

At the Warcha mine, which is a replica of the one at Khewra on a small scale, mechanical methods have also been introduced. Here, the presence of faults is likely to curb extension. The writer suggests, however, that important quantities of salt still exist in the main (lower) seam below the old Sikh workings. Pro pecting in the Jansukh valley, about one and a half miles north-east of the mine, has given promising results, a seam of good quality over 75 feet thick, having been proved.

The excavation of potash salts, to which reference was made in the review for 1919-1923, has been discontinued.

Kalabagh, Mianwali district.

Regarding Kalabagh, the exploitation of the seams of rocksalt within the mine continued during the quinquennium. The workable area is here very limited, the salt deposits being cut off by a large fault. The dip of the seams is, however, almost vertical; future exploitation will, therefore, depend mainly on the extent to which development is economically practicable in depth. With the

[1] *Ibid.*

object of opening up further resources, the driving of exploratory drifts in the vicinity of Kalabagh town, on the west side of Kalabagh hill, was recommended[1]. The work is now in progress and a 40-foot seam of salt has been proved in one of the drifts; much salt-bearing marl yet remains to be penetrated.

Production and distribution.

The production of rock-salt in the Salt Range remained fairly steady throughout the quinquennium. The average output constitutes about 10 per cent. of the total production of India, excluding Aden. Of the Salt Range total, nearly three-quarters come from the Khewra mine. At present, very little of the Khewra output is distributed into eastern India beyond the United Provinces. The Indian Tariff Board had, however, recommended that the output of the Mayo mine should be increased and that a crusher plant should be installed in order to provide pulverised salt for the Bengal market. During the latter part of the quinquennium, attempts were made to instal a suitable plant capable of dealing with a daily output of 500 tons of rock-salt. Owing to certain mechanical defects, the plant has so far proved unsatisfactory.

Kohat salt.

In the Kohat district, the quantity of rock-salt quarried during the period 1929-1933—amounting to nearly 21,000 tons—remained about the same as in the previous quinquennium. Approximately two-thirds of this total is produced at Jatta, the greater portion of the remainder coming from Bahadur Khel, and a small amount from Kharak. At Jatta, attempts to mine the salt were commenced in June, 1925. Considerable difficulties were, however, encountered and, following an examination of the area in 1933, further efforts to mine the deposit by underground workings were abandoned. Large quantities of salt, suitable for excavation by open workings, exist in these Kohat areas. The Kohat salt is consumed mainly in the North-West Frontier Province, some is also despatched to the tribal territories and a small amount to Afghanistan.

A report having been received to the effect that salt was being manufactured in Waziristan, an officer of the Northern India Salt Revenue Department visited the locality. He reported that the salt site is situated in the territory of Kot, a cluster of Mahsud villages 35 miles north of Sorarogha Scouts Post. It consists of a small spring of brine emanating from a conglomeration of stones

[1] *Loc. cit.*

and clay at an old subsidence above the bed of the Shaktu. No sign of salt marl or exposure of rock-salt was observed.[1]

Details of imports.

The markets of Bengal and Burma are supplied largely from Aden and foreign countries. In the quinquennium 1924-1928, these imports constituted about 30 per cent. of India's total consumption. The corresponding figure for the quinquennium under review is about 27 per cent., that is about 549,000 tons. Of this total, about 85 per cent. is imported into Bengal and most of the remainder into Burma.

TABLE 104.—*Average annual imports of Salt during 1924 to 1928 and during 1929 to 1933.*

—	1924 to 1928.		1929 to 1933.	
	Quantity.	*Per cent. of total.*	Quantity.	*Per cent. of total.*
	Tons.		Tons.	
United Kingdom	82,656	*14·2*	36,325	*6·6*
Germany	47,698	*8·2*	61,078	*11·2*
Spain	52,106	*9·0*	37,394	*6·8*
Aden and Dependencies	193,850	*33·4*	253,135	*46·1*
Egypt	130,205	*22·4*	63,714	*11·6*
Italian East Africa	54,246	*9·3*	82,914	*15·1*
Other countries	20,182	*3·5*	14,228	*2·6*
Average annual total	**580,943**	*100·0*	**548,788**	*100·0*

From Tables 100 and 101, it is apparent that the import duty on salt from abroad imposed during the quinquennium, has so far had no *marked* effect on the production of India (excluding Aden) as a whole, though to some extent it appears to have assisted the industry of northern and western India. On the other hand, Aden producers have profited handsomely at the expense of the United Kingdom and foreign countries, particularly the United Kingdom and Egypt, imports from abroad showing a fall of 24 per cent. when compared with the average for 1924-1928.

Imports into Bengal.

This effect is seen from a study of the import figures for Bengal (*see* Table 105).

[1] Unpublished report furnished by the Commissioner, Northern India Salt Revenue Department.

TABLE 105.—*Details of imports of Salt into Bengal from 1929-30 to 1933-34 (in tons).*

Whence imported.	1929-30.	Per cent. of total.	1930-31.	Per cent of total.	1931-32.	Per cent. of total.	1932-33.	Per cent. of total.	1933-34.	Per cent. of total.	Annual average.	Per cent. of total.
Aden . .	216,763	36 29	178,510	27·92	305,984	61·62	290,858	50·63	282,487	62·31	*254,921*	47·75
Bombay .	28,255	4·73	21,318	3·34	33,792	6·82	13,097	2·27	15,755	3·47	*22,443*	4·13
Karachi . .	17,345	2 90	16,227	2 53	27,815	5·61	34,737	6·04	31,257	6 89	*25,477*	4·79
Okha . .	6,767	1 13	6,101	0 95	13 032	2 63	33,798	5·89	38,183	8 42	*19,576*	3·81
Nadir . .	..	..	..	..	..	..	3,583	0·62	12,732	2·80	*3,263*	·69
Navalakhi .	..	..	..	..	7,182	1·44	7,078	1·23	13,167	2 89	*5,485*	1·11
Tuticorin .	3,127	0·52	..	..	16,658	3 36	14,784	2·59	10,949	2 40	*9,103*	1·77
Foreign ports.	325,049	54 43	417,259	65·26	92,196	18 52	176,515	30·74	48,728	10·82	*211,950*	35·95
Total .	**597.306**	100 00	**639,415**	100·00	**496,659**	100 00	**574,430**	100·00	**453,258**	100·00	*552,218*	100·00

Following the imposition of the import duty on salt from abroad in March, 1931, imports from foreign countries fell very considerably. During the two years prior to the introduction of this extra duty, they averaged about 60 per cent. of the total salt imported into Bengal, whilst during the three years following, the average was only 20 per cent. For the same periods, imports from Aden rose from an average of 32 per cent. (1929 to 1930) to about 58 per cent. (1931 to 1933). Appreciable, though much smaller increases occurred in the case of the other Indian ports. Of the diminished imports from abroad, Liverpool and Spain were most affected, the imports from those places being negligible in the year 1933-34. Of the salt imported into Bengal, about 90 per cent. comes to Calcutta, the remainder *via* Chittagong. About two-thirds of the total imports are consumed in Bengal and Assam, the remainder goes to Bihar, Nepal and the eastern part of the United Provinces.

Imports into Burma.

Of an average annual importation of about 80,000 tons of salt into Burma during the period 1929 to 1933, by far the greater proportion was foreign salt. An appreciable amount was supplied by Aden during the early part of the quinquennium but in 1932-33 the receipts from that source were *nil*. Germany, Italy, East Africa and Port Said were the principal importers.

Civil Disobedience Movement; Delhi Pact.

During the quinquennium—1929 to 1933—under review, considerable public interest, centring largely around the possibility of making India self-supporting in regard to the salt consumed, has been directed towards the salt industry of India. In order to advise Government on this question, the Indian Tariff Board made a detailed examination of the industry during the cold weather of 1929-30. Interest in the salt industry was further aroused, during the financial year 1930-31, by the Civil Disobedience campaign which was largely directed against the Salt Laws. The agitation engendered by this movement to some extent adversely affected the sales of the factories in Southern India over a short period, and was also reflected slightly in north-west India in the fall of revenue from local consumption. The movement terminated with the Delhi Pact in March, 1931 and, in accordance with that agreement, certain concessions regarding the manufacture of duty-free salt for local consumption were made by Government. In most areas, the effect of these concessions has been negligible, but in a few instances, parti-

cularly in Sind, and also to some extent in the Arakan Division of Burma, loss of revenue in recent years has been attributed to their abuse.

Indian Tariff Board report.

In view of the fact that the recommendations of the Indian Tariff Board, in 1929-30, resulted in the inception of certain measures by Government with the object of encouraging the production, in India, of salt suitable for consumption in those markets which are at present largely supplied from abroad, it would not be out of place to include, in this review, a brief summary of the activities of the Board. In the preamble of their Report, the Board state[1] :—

'The principal markets in India which rely on imported salt are the Bengal and the Burma markets. The Board proposes to commence this enquiry by investigating conditions in India, leaving for consideration at a later date the problem of imported salt in Burma. The import of fine white crushed salt from abroad into Bengal is about 120 lakhs of maunds and of white uncrushed salt (*kurkutch*) about 12 lakhs of maunds annually. In the main therefore the problem before the Board is to determine whether it is desirable in the national interest that steps should be taken to encourage the production of fine white crushed salt in India.'

This type of salt includes :—

(*a*) Brine salt such as Liverpool and Hamburg salt ; and

(*b*) Solar salt such as Port Said, Aden and other Red Sea salts.

During the past 40 years, the cheaper solar salts (*b*) have tended to replace the more expensive brine salts (*a*).

The Tariff Board came to the conclusion that salt of a quality suitable for the Bengal market can be manufactured by solar evaporation in India where brine supply is available and they suggested Karachi and Okha as possessing certain natural advantages. In addition, they were of the opinion that rock-salt from the Khewra mines, when crushed, compares favourably with Liverpool salt. They considered that the annual output of railborne salt (*i.e.*, from Khewra, Sambhar and Pachbadra) could be increased by 150,000 tons and that this salt, if crushed, would also be suitable for the Bengal market. They were of the opinion that the output of the existing works at Karachi and Okha could be increased to approximately 150,000 tons annually.[2]

[1] Report of the Indian Tariff Board on the Salt Industry, p. vii, (Govt. of India Central Publication Branch, 1930).

[2] *Ibid.*, p. vii.

Salt Survey Committee.

On the recommendation of the Tariff Board, for the purpose of investigating the possibilities of existing sources of supply in India and the effect of such expansion on prices, the Salt Survey Committee was appointed. In their report, made in February, 1931, the Committee came to the conclusion that—

'there is no ground for assuming that, with imports from Aden, India cannot easily be made self-supporting in the matter of salt supply, and that even the continent itself can, when areas suitable for salt manufacture but at present lying idle are developed, supply all the crushed salt that India needs.'[1]

Possibility of manufacture of salt in Bengal.

During the cold weather of 1931-32, a further investigation into the possibilities of salt production in Bengal and in Bihar and Orissa was carried out by Mr. C. H. Pitt. The latter's conclusions[2] corroborate the results of a previous investigation by Dr. R. L. Datta.[3] Mr. Pitt's opinion was to the effect that the meteorological data rule out immediately the possibility of salt manufacture, by solar evaporation only, on the coast between Calcutta and Balasore, whilst the cost of evaporation by artificial means is prohibitive except, perhaps, in the supply of very local demands. Regarding the manufacture of salt by solar evaporation in the vicinity of the Chilka lake in Orissa, he observed that such was in vogue until 1897, and he suggested the possibility of supplying Orissa from this source.

Salt manufacture in Bengal.

During 1931, with a view to promoting a salt industry in the province, an association the Bengal Salt Manufacturers Association was formed and obtained the grant of a temporary permit for the manufacture of salt as an experimental measure in the districts of 24-Parganas and Midnapore. Later, other applicants were given temporary permits. Of these, the Premier Salt Manufacturing Co. opened two factories in January, 1933, one at Sandhiachak in the Tamluk sub-division, the other at Kadua on the sea-board near Contai. Production from the former factory has already ceased, apparently on account of the high cost of production, but from the Kadua works a small production of a few hundred maunds was produced during January to early April, 1933. During the following financial year,

[1] See *Capital*, Ind. Industries Trade and Transport, Suppl lt., p. 45, (December, 1931).
[2] Report on the investigations into possibilities of Salt production in Bengal and Bihar and Orissa, by C. H. Pitt, (Govt. of India, Central Pubn. Branch, Calcutta, 1932).
[3] Govt. of Bengal, Industries Dept., Bull. 26, p. 5, (1927).

744 maunds of salt were produced. The salt is manufactured from saline earth scraped from the sea beach. After lixiviating with water and filtering, the solution is boiled, using coal as fuel. It is very improbable that this form of manufacture will prove a commercial success.

Saltpetre.

[E. R. Gee.]

Formation.

The conditions necessary for the natural formation of potassium nitrate in a soil are :—

(i) a supply of nitrogenous organic matter,

(ii) the presence of potash.

(iii) climatic conditions favourable to the growth and action of nitrifying bacteria,

(iv) meteorological conditions suitable for the efflorescence of the salt at or near the surface.

An ideal combination of these necessary circumstances has made the Bihar section of the Gangetic plain famous for its production of saltpetre. In this part of India we have a population of over 600 per square mile mainly engaged in farming and agriculture, and thus accompanied by a high proportion of domestic animals supplying an abundance of organic nitrogen. The requisite potash is derived from the staple fuel, which consists very largely of cow-dung and wood. With a mean temperature of 78°F. during a large part of the year, and a comparatively high humidity combined with a low diurnal range in temperature, conditions in the Bihar plain are unusually favourable for the growth of nitrifying micro-organisms. The soil around villages would naturally be well-stocked with potash, and with a period of continuous surface desiccation following a small rainfall, the sub-soil water, brought to the surface by capillary action in the soil, leaves an efflorescence of salts of which potassium nitrate forms a conspicuous proportion. Similar conditions obtain in parts of Egypt. The saltpetre industry has flourished for centuries in India, and received a marked impetus during the days of the American Civil War, when the salt was an essential ingredient of all explosives and when India practically held a monopoly of its production.[1]

[1] P. C. Tallents; Census of India, 1921, Vol. VII, Pt. I, p. 25.

The houses of Indian villages consist for the most part of mud and, as a consequence, frequently tumble down and have to be renewed. The village site thus becomes gradually raised, and as the floors of the houses are frequently made of mud and cow-dung, there is built up a nitrogenous deposit, which is reinforced by other forms of animal refuse and to which are added the wood ashes of innumerable fires. The decaying refuse undergoes nitrification, and the product drains from these raised village sites into lower levels and separates out as an efflorescence consisting largely of sodium chloride, sodium sulphate and nitrates of potash and magnesium. The accumulations in some of the old village sites are the results of hundreds of years.

Manufacture.

The earths from which the crude saltpetre is extracted contain sometimes as much as 29 per cent., sometimes as little as 1 per cent., but not often more than 5 per cent. of nitrate. The process of extraction is described by C. M. Hutchinson.[1] Wood ashes are added to decompose any calcium nitrate in the earth, and the approximate proportions of the various salts in the drainage liquor are :—

	Per cent.
Sodium chloride	15·25
Potassium nitrate	7·24
Potassium chloride	0·40
Magnesium chloride	0·20
Calcium chloride	0·10
Calcium sulphate	0·10
Magnesium sulphate	0·10

On evaporation sodium chloride first crystallises out, and the nitrate is obtained later ; the sodium chloride is consumed locally. The crude saltpetre varies greatly in composition, and always contains a considerable amount of sodium chloride. The following are analyses of high and low grade crude saltpetre :—

	High grade. Per cent.	Low grade. Per cent.
Potassium nitrate	66·07	26·86
Magnesium nitrate	2·54	12·24
Sodium chloride	21·84	34·80
Sodium sulphate	3·65	11·20
Insoluble matter	0·90	1·40
Water	5·00	13·50

[1] *Agric. Res. Inst. Pusa*, Bull. No. 68, (1917).

Some of this crude saltpetre (*kuthea*), which may contain from 30 to 50 per cent. of foreign matter, is used as a fertiliser but most of it is sent to refineries for the manufacture of gun-powder. The crude earths (*lona mati*), from which this saltpetre is extracted by lixiviation, are also used on the spot for manurial purposes in north-western India, especially in the upper Doab where the people are well-to-do, and in parts of Bihar. According to Mukerji[1] it has been found more satisfactory to use nitrate manure in a comparatively pure form. The typical conditions for the formation of nitrate in the Bihar plain are repeated in the Punjab and the United Provinces. These two areas are, in fact, reported to turn out almost as much as Bihar.

Production.

Regarding production, in the case of the principal producing areas, figures for the refined product are available in the Annual Reports of the various Salt Departments. The details for the period 1929-30 to 1933-34 are given in the following table :—

TABLE 106. *Quantities of refined saltpetre produced in Northern India during 1929-30 to 1933-34 (in tons).*

Circle.	1929-30.	1930-31.	1931-32.	1932-33.	1933-34.	Annual average.
Punjab . . .	3,475	3,980	4,126	5,358	6,746	*4,793*
United Provinces . .	1,411	2,476	2,135	1,886	2,206	*2,019*
Bihar	572	853	1,091	1,477	2,311	*1,261*
TOTAL .	**5,458**	**7,309**	**7,652**	**8,651**	**11,263**	***8,073***

Madras.

In the case of the Punjab, the refined saltpetre represents about 32 per cent. of the crude product; the corresponding figures for the United Provinces and Bihar were 48 per cent. and 50 per cent. respectively. In Madras, where crude saltpetre is manufactured mainly in the Coimbatore and Madura districts by lixiviating alkaline soils, there was a definite decline in the number of licenses issued for both the crude and the refined products. This decline continued throughout the quinquennium and, in the year 1933, only 37 licenses were issued against 54 in 1929, and 72 at the end of the previous quinquennium. The industry forms only a part-time occupation of the poor people of the Uppliar class who sell the crude product to refiners.

[1] N. G. Mukerji, 'Indian Agriculture,' (1901).

During 1929-30, only one licensed refinery—the Bengal Chemical & Pharmaceutical Works, Ltd., Calcutta—was in existence and the production from these works was only 23 maunds of refined saltpetre as compared with 810 maunds in 1928-29. Production from this source rose to 76 maunds in 1931-1932, but fell rapidly in the two subsequent years and in 1933-1934 the license was not renewed.

Bengal.

Under the supervision of the Northern India Salt Revenue Department are the refineries of Northern India, the United Provinces and Bihar (*see* Table 106). In 1929-30, there was an appreciable improvement in the industry in the Punjab. In 1931, under the Delhi Pact, licenses to *luniyas* for the manufacture of crude salt and saltpetre for local consumption were dispensed with and statistics of the number of concerns manufacturing the crude product are not available. Till the end of the year 1929-30 the demand for Punjab saltpetre was brisk, during 1930-31 prices fell and also the demand and by the end of that year the industry was in a state of acute depression, doubtless connected with the general world-wide depression in trade. During the same period in the United Provinces, the number of licenses issued increased slightly, as also in Bihar, but not to the extent that might have been expected in view of the fact that Government had given assistance to the industry by reducing licensing fees and securing reductions in railway freights. An increase in output, particularly from the factories employing solar evaporation methods of manufacture at Lahore, Amritsar and Kaithal, occurred during the latter part of the quinquennium.

Punjab, United Provinces, and Bihar.

Saltpetre is made on a small scale by the Kachins of the Northern Shan States. An account of the process is given in the Review of the Mineral Production of India for 1924-28.[1]

Burma.

The excavation of potassium salts in the Mayo salt mine at Khewra, Punjab, has never been revived since the war.

The total Indian production for the year 1924,[2] quoted in the previous quinquennial review, was 8,512 tons.

Analyses by Dr. W. A. K. Christie have shown the Sambhar lake brines to contain 0·18 to 0·55 grams of potassium per litre, in

[1] *Rec. Geol. Surv. Ind.*, LXIV, p. 292, (1930).
[2] *Loc. cit.*, p. 292.

Potassium salts at Sambhar, Rajputana. the form of chloride, sulphate and carbonate. Recent analytical work by Dr. P. K. Ghosh shows that these salts become concentrated in the impure *reshta* salts that crystallise along the margins of the salt pans; the K_2O content in the latter being calculated, in the case of two samples, at 8·19 and 7·30 per cent.[1]

Exports. There has also been a serious decline in exports since the war when, during 1914-1918, the manufacture of explosives gave a stimulus to production and the average yearly export amounted to 21,737 tons. During the quinquennium 1924-1928, exports fell from 8,385 tons at the beginning of that period to 4,478·5 tons in 1928, the value falling from £201,382 in 1924 to £74,629 in 1928. During the quinquennium 1929-1933, exports recovered from a minimum of 3,827 tons in 1930 to 9,478 tons in 1933, the average for the quinquennium—6,467 tons—being somewhat in excess of the corresponding figure 6,061 tons for 1924-1928. The average annual value of the exported saltpetre, however, fell from £127,221 during 1924-1928 to £81,597 during 1929-1933, that is from nearly £20 to £12·6 per ton.

Regarding the distribution of the exported saltpetre, by the end of the previous quinquennium, Ceylon absorbed nearly three-quarters of India's total. During 1929-1933, markets in the United Kingdom were regained to an appreciable extent and, in addition, trade with Mauritius increased considerably, so that by the end of the quinquennium the United Kingdom was absorbing 31·5 per cent. of the Indian exports, Mauritius 46·2 per cent., whilst despatches to Ceylon accounted for only 8·7 per cent. (*see* Table 107).

The average annual exports from the different provinces during the period 1929-1930 to 1933-1934 have been :—

	Tons.
Bengal	4,953·9
Sind	1,360·3
Bombay	182·0
	6,496·2

As will be observed from the above-quoted statistics, Bengal continues as the principal exporting province, largely *via* Calcutta. Exports from Karachi have increased appreciably, apparently at the expense of both Calcutta and Bombay.

[1] *Rec. Geol. Surv. Ind.*, LXVIII, Pt. 2, p. 245, (1934).

TABLE 107.—*Distribution of Saltpetre exported during the years 1929 to 1933.*

	1929.			1930.			1931.		
	Quantity.	*Value.*	*Per cent. of total quantity.*	Quantity.	*Value.*	*Per cent. of total quantity.*	Quantity.	*Value.*	*Per cent. of total quantity.*
	Tons.	*Rs.*		Tons.	*Rs.*		Tons.	*Rs.*	
United Kingdom . . .	1,302·7	*2,93,854*	*28·4*	1,055·0	*2,24,167*	*27·6*	1,324·9	*2,10,274*	*21·5*
Ceylon	2,985·5	*5,66,286*	*65·1*	2,437·4	*4,13,315*	*63·7*	2,774·0	*3,33,657*	*45·1*
Straits Settlements (including Labuan).	111·8	*29,008*	*2·4*	126·9	*22,681*	*3·3*	85·1	*14,998*	*1·4*
Mauritius and Dependencies .	127·2	*30,880*	*2·8*	168·4	*48,704*	*4·4*	1,918·9	*4,14,614*	*31·1*
Other countries . . .	58·2	*21,023*	*1·3*	39·2	*12,634*	*1·0*	52·9	*17,544*	*0·9*
TOTAL .	**4,585·4**	*9,61,051*	*100·0*	**3,826·9**	*7,21,501*	*100·0*	**6,155·8**	*9,91,087*	*100·0*
Total value in Sterling . .	..	*£71,720*		..	*£53,445*	..	..	*£73,414*	..
		£1 = Rs. 13·4			£1 = Rs. 13·5			£1 = Rs. 13·5	

	1932.			1933.			Average.		
	Quantity.	*Value.*	*Per cent. of total quantity.*	Quantity.	*Value.*	*Per cent. of total quantity.*	Quantity.	*Value.*	*Per cent. of total quantity.*
	Tons.	*Rs.*		Tons.	*Rs.*		Tons.	*Rs.*	
United Kingdom . . .	2,791·6	*4,25,567*	*33·7*	2,991·7	*5,07,289*	*31·5*	1,893·2	*3,32,230*	*28·5*
Ceylon	1,818·6	*2,09,327*	*21·9*	821·9	*1,10,912*	*8·7*	2,167·5	*3,26,699*	*40·9*
Straits Settlements (including Labuan).	167·3	*12,071*	*2·0*	166·9	*44,345*	*1·8*	131·6	*30,613*	*2·2*
Mauritius and Dependencies .	2,835·8	*3,56,597*	*34·2*	4,377·7	*5,75,192*	*46·2*	1,885·6	*3,15,258*	*23·7*
Other countries . . .	675·8	*1,63,499*	*8·2*	1,120·1	*3,20,181*	*11·8*	389·2	*86,976*	*4·7*
TOTAL .	**8,289·1**	*12,37,331*	*100·0*	**9,478·3**	*15,57,919*	*100·0*	**6,467·1**	*10,91,776*	*100·0*
Total value in Sterling . .		*£92,272*	.	.	*£117,136*	..	.	*£81,597*	..
		£1 = Rs. 13·3			£1 = Rs. 13·3				

Small quantities of saltpetre for chemical and medicinal purposes are imported by sea. Owing to the fact that the mineral is not separately specified in the import trade returns for British India but is recorded along with other potassium compounds, statistics are, however, not available. Saltpetre is also imported from Nepal, but figures are, unfortunately, no longer available. During the period 1919-20 to 1923-24, such imports amounted to an annual average of 3,981 cwts.

Imports.

A certain amount of refined as well as crude saltpetre is used for agricultural purposes in India especially on the tea estates. During the previous quinquennium the amounts used in tea-gardens fell from about 1,100 tons in 1924 to 250 tons in 1928. For the quinquennium under review, the estimated consumption was as follows:-

Consumption in India.

Year.	Tons
1929	300
1930	800
1931	680
1932	730
1933	450

It is, apparently, now found to be cheaper to employ a mixture of imported sulphate of ammonia and nitrate of potash.

Silver.

[E. L. G. Clegg.]

There are no known occurrences of silver-ores mined primarily as ores of silver, in India, the metal being obtained entirely as a by-product in the mining of gold- and lead-zinc-ores. Over 99 per cent. of the Indian silver production is obtained from the argentiferous lead-zinc-ores of the Bawdwin mine, Northern Shan States, Burma. The reader is referred to the article on lead (page 167) for a description of the ore-body and its development at this mine. The remainder of the silver output is obtained from the gold-ores of the Kolar field, in Mysore; the contribution from this latter source is insignificant compared with that of Bawdwin as will be seen from Table 108 showing the silver production of India by localities.

The average output of silver from Kolar during the period under review was 22,443 ozs. valued at Rs. 30,984 and shows a slight increase in output but decrease in price on the previous figures of 21,956 ozs. valued at Rs. 37,931. The output from Bawdwin, which reached a maximum of 7,280,517 ozs. valued at Rs. 1,07,31,482 in 1929, followed the vicissitudes of the lead, zinc, and copper outputs from which it was recovered. The average output of 6,457,625 ozs. valued at Rs. 72,84,827 shows a fairly large increase in output, but a big decline in value as compared with the 5,726,414 ozs. valued at Rs. 1,01,61,284 of the previous quinquennium.

Production.

During 1929-1933, silver reached the lowest price ever known. Starting the year 1929 at $26\frac{5}{16}$ pence per standard ounce, it fell steadily throughout the year to $22\frac{5}{8}$ pence in December. The world's output of virgin silver reached the record figure of 261,715,021 fine ozs. owing to record outputs of the base metals copper, lead, and spelter from which it is mostly derived. Added to this, 31,000,000 fine ozs. of demonetized silver were put on the market by the Government of India. In 1930 the decline still continued and the price on December 31st reached $14\frac{7}{16}$ pence per oz. The output for the year was 315,000,000 fine ozs. although the production of virgin silver registered was only 240,000,000 fine ozs. A fall in price had been anticipated owing to the conversion of the Indian rupee to a gold basis but not to the extent realised. A worse year, 1931– the worst in the history of the metal—followed, when the price per oz. fell to 12 pence in February, but rose in value on England going off the gold standard, to over 20 pence, the average for the year being $14\frac{9}{32}$ pence per oz. The Government of India sales amounted to 35,000,000 fine ozs. and the output of 255,500,000 fine ozs. included 59,500,000 ozs. of secondary metal. The main factor in depressing prices during 1930-31 was stated to be the sales made by the Government of India to support the rupee based on gold.

World's production and prices.

In 1932, although the average price in sterling at $17\frac{27}{32}$ was higher than in 1931, in terms of gold it reached a record low price of $24\frac{1}{4}$ cents gold at the end of the year. Production showed a heavy decline in both virgin and secondary output, the former to 161,000,000 and the latter to 22,000,000 fine ozs. Indian

TABLE 108.—*Quantity and Value of Silver produced in India during 1929 to 1933.*

—	Average for 1924 to 1928.		1929.		1930.		1931.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Ozs.	*Rs.*	Ozs.	*Rs.*	Ozs.	*Rs.*	Ozs.	*Rs.*
Bihar and Orissa— Manbhum	..	..	..	..	..	..	..	..
Burma— Northern Shan States	5,726,414	*1,01,61,284*	7,280,517	*1,07,31,482*	7,054,206	*76,87,674*	5,900,400	*51,97,367*
Madras— Anantapur	96	*150*	..	..	..	..	..	..
Mysore— Kolar	21,956	*37,931*	17,810	*25,155*	17,844	*20,894*	22,605	*31,867*
TOTAL	**5,748,466**	*1,01,99,365*	**7,298,327**	*1,07,56,637*	**7,072,050**	*77,08,568*	**5,923,005**	*52,29,234*
	..	*£756,148*	..	*£802,734 (£1 = Rs. 13·4)*	..	*£571,005 (£1 = Rs. 13·5)*	..	*£387,351 (£1 = Rs. 13·5)*

—	1932.		1933.		Average for 1929 to 1933.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Ozs.	*Rs.*	Ozs.	*Rs.*	Ozs.	*Rs.*
Bihar and Orissa— Manbhum	..	..	22	*30*	4	*6*
Burma— Northern Shan States	5,998,956	*62,32 915*	6,054,047	*65,74,695*	6,457,625	*72,84,827*
Madras— Anantapur	..	..	..	..	..	..
Mysore— Kolar	27,781	*38,796*	26,172	*38,210*	22,443	*30,984*
TOTAL	**6,026,737**	*62,71,711*	**6,080,241**	*66,12,935*	**6,480,072**	*73,15,817*
	..	*£471,557 (£1 = Rs. 13·3)*	..	*£497,213 (£1 = Rs. 13·3)*	..	*£545,972*

TABLE. 109.—*Exports and Imports of Silver in thousands of rupees from 31st March, 1929 to 31st March, 1934.*

—	1929-30.	1930-31.	1931-32.	1932-33.	1933-34.
Imports—					
Private	13,36,39	13,45,92	4,41,90	1,62,87	81,15
Government	5,52	71	74	8	57
TOTAL	13,41,91	13,46,63	4,42,64	1,62,95	81,72
Exports—					
Private	1,47,36	1,81,33	1,82,60	90,03	79,79
Government	3,32,42	1,57,36	3,02,21	2,74,23	6,37,65
TOTAL	4,79,78	3,38,69	4,84,81	3,64,26	7,17,44
Balance	—8,62,13	—10,07,94	+42,17	+2,01,31	+6,36,72

Government sales were 42,000,000 fine ozs. and Indian consumption which was 57,000,000 ozs. in 1931 fell to 12,000,000 ozs. in 1932. For the first time in their history, the Burma Corporation failed to dispose of their output of silver in India, the country they had hitherto regarded as their natural market. In 1933 the price rose slightly to $18\frac{5}{32}$ whilst the production of virgin silver following the slightly increased production of base metals rose to 163,000,000 ozs. The amount of secondary silver coming into supply was estimated at the huge total of from 113,000,000 to 123,000,000 fine ozs.

Exports and imports of silver.

Table 109 shows the value of Indian imports and exports of silver from 31st March, 1929 to 31st March, 1934 in thousands of rupees. It illustrates in striking manner how, in the period under review, India changed from being one of the world's largest absorbers of silver to one of the world's largest exporters.

Tin.

[E. L. G. Clegg.]

Tenasserim deposits.

The cassiterite deposits of Burma, which furnish practically the whole of India's production of tin, have been worked from a remote antiquity, especially in the districts of the Lower Tenasserim division. The region through which the Burmese tin-ore is disseminated corresponds exactly with that described in another section of this review in the case of wolfram, for the ores of tungsten and tin are most intimately associated and are of identical origin. The granitic mountain ranges of Lower Burma are the northern continuation of the same rocks which have yielded the rich and well-known tin-stone deposits of the Malay Peninsula and western Siam. The sporadic occurrences of cassiterite in India proper are not of any economic importance.

It has again to be recorded that despite the low prices obtainable for tin concentrates for the middle portion of the period under review and despite the depression through which the industry as a whole passed during this period there has again been a big rise in the average annual output. Owing to the unfavourable prices

ranging during the middle period there has however been a considerable fall in the value per ton of this output. The production figures for Burma as a whole give no indication of the depression the industry suffered during the period and a short recapitulation of what is now ancient history regarding the industry in general during recent times is necessary before discussing Burma statistics in detail, as although the effects have not been so greatly felt in Burma as in the world's chief producing countries, the results as a whole may be very far-reaching and decide the policy of the industry in the future.

World's production and prices.

The year 1922 saw the last occasion of a slump in the tin industry. In 1921 an annual world's production of 99,728 tons was recorded whilst the average price of the metal for the year was £165-5-4; in 1922 the production rose to 130,660 tons, over-production causing the price to fall to £159-10-9. During this slump period in order to reduce the available stocks of tin a supplementary stock of 17,600 tons was formed in the East under the Bandoeng agreement. As the price of tin rose in 1923, the parties to the agreement released tin at the rate of 5 per cent. per month commencing from 1st April, 1923, complete release being effected by 1st November, 1924, 20 months later. Meanwhile, production in 1923 fell to 125,747 tons and the price rose to an average of £202-5-0 per ton. Thereafter the price rose steadily to £248-17-4 in 1924, £261-1-6 in 1925 and £291-2-0 in 1926, whilst a fairly steady output of about 143,000 tons annually was registered during the same period.

Prospects in the industry were bright; existing concerns extended their operations and new companies entered the industry. In 1927 an increase in production to 157,173 tons took place and although the average price for the year at £289-1-5 differed little from the average for the previous one, there was a fairly steady drop from the maximum price of £313-9-5 of March to £267-4-10 at the close of the year. In 1928, output increased to 178,050 tons, a new maximum despite a further fall in price of about £62, the average for the year being £227-4-3. All important producers increased their outputs and continued to do so during 1929, when the peak year in production, 190,306 tons, was reached. The price, however, dropped steadily from £225-15-0 at the beginning of the year to £178-2-6 at the close, the average being £203-18-8. The effects of the extensions and new operators occasioned by the rising price

of tin from 1922 to 1926, were now making their presence felt in no uncertain manner in the production figures, and the increase of the margin of supply over consumption that had been apparent in 1927 and 1928 greatly increased. Consumption had definitely not kept abreast of production and in July, 1929, the Tin Producers Association was formed with the object of balancing supply and demand. Shortly after the formation of this association the financial crisis in America which heralded the great world depression of 1930-1932 further aggravated the situation, as the balance had now to be struck between an increasing production with a greatly decreasing demand. A voluntary restriction scheme was entered into between the British producers of Malaya and Nigeria and the foreign producers of Bolivia and the Netherlands East Indies. These, as will be seen from the following table, are the greatest producing countries and include the countries which were most responsible for the greatly increased production.

TABLE 110.—*World's production of Tin for 1922 and 1929.*

	1922.	1929.	Increase or Decrease.
	Tons.	Tons.	
Federated Malay States	35,288	67,044	+31,756
Unfederated Malay States	1,991	2,325	+334
Bolivia	31,942	46,338	+14,396
Netherlands East Indies	32,510	34,952	+2,442
Siam	5,947	9,940	+3,993
Burma	1,001	2,335	+1,334
Nigeria	5,614	10,504	+4,890
China	12,435	6,250	—6,185
Australia	2,657	2,500	—157
Cornwall and Devon	370	3,271	+2,901
Congo	..	1,000	+1,000
South Africa	328	1,196	+868
Spain and Portugal	600	1,500	+900
Indo-China and Japan	..	751	+751
South-west Africa	..	200	+200
East Africa	..	200	+200
TOTAL	130,683	190,306	+59,623

Despite all efforts of voluntary restriction, production in 1930 was only reduced to 173,129 tons, the decline being registered in

the countries where the policy of restriction was pursued, whilst the decrease in consumption had been considerably greater than that of production, and the price had again fallen, the average for the year being £141-19-0. The ineffectiveness of the voluntary restriction scheme had been early apparent and in June, 1930, a committee had been formed to investigate the possibilities of a form of international restriction. By the end of the year a scheme had been formulated which led to the creation of an International Tin Committee and a compulsory restriction scheme on a quota system by the British, Dutch and Bolivian Governments. This scheme came into force on 1st March, 1931, the world's production for 1929, agreed at 186,518 tons of metal, being taken as the basis for restrictive calculations. The individual quotas on this basis were changed slightly, Bolivia and Nigeria giving up a part of their quota to the Netherlands East Indies as the latter maintained that they were not responsible for over-production and were proving a little difficult. The final individual working tonnages for the restricting countries then became—

International Tin Committee.

Malaya	69,345 tons calculated at 72 per cent.
Nigeria	10,293 ,, ,, 70 ,, ,,
Netherlands East Indies	38,469 ,, ,, 71·4 ,, ,,
Bolivia	46,338 tons calculated on true assay.

Subsequently in September, 1931, Siam, another country which had substantially increased its output, agreed to become a party to the International scheme in so far as she agreed to restrict her exports to 10,000 tons per annum.

On 1st March, 1931, when the scheme first operated, the world's basic tonnage was taken as 145,000 tons, when the sum of the quotas for the four controlled countries became 125,454 tons. On 1st June, this basic tonnage was reduced to 125,454 tons and the quotas of the four controlled countries to 105,845 tons. Despite this heavy restriction the decline in consumption was so great that over-production still continued. The price continued to fall, the average for the year being £118-8-11 per ton, although there had been an appreciable rise in sterling price during the last quarter of the year on England going off the gold standard. Production for the year was 147,917 tons, whilst an International Tin Pool working in conjunction with the International Tin Committee had by the end of the year accumulated stocks of tin amounting to

21,000 tons. In 1932 progressive intensification of restriction continued. From 1st January to May, there was a combined quota cut of 15,000 tons; in June, there was a further cut of 20,000 tons and, from July to the end of the year, a still further cut of 17,000 tons. The total output of the restricted countries for the year amounted to 77,238 tons and the world's output to 93,987 tons. The average sterling price of tin for the year was £135-18-7, a decline over the 1931 figure when considered in terms of gold, the New York price being 22 gold cents per lb. as against 24 gold cents in 1931. Prices were however slightly higher in the second half of the year and stocks at the year-end were somewhat reduced.

The next year, 1933, saw the realisation of the International Tin Committee's object. Throughout the year world stocks of tin continued to decline and the price, which received an added and great impetus owing to the big demand for tin from America on the latter country going off the gold standard, to rise. For the first half of the year restricted countries were reduced to 40 per cent. of their standard tonnages and for the second half to 33 per cent. The severity of this restriction can be better appreciated when it is realised that most of the restricted countries could produce more than their standard tonnages owing to new producers coming into operation since 1929, and restriction to 33 per cent. in such cases practically amounted to 25 per cent. of their potential capacity. The world's total production for 1933 was 87,341 tons, the lowest world's output since 1899. Of this total, the restricted countries produced 67,337 tons. The annual average price of standard tin in London was £194-12-0, an increase of £58 over the 1932 rate.

The International Tin Pool, in accordance with the agreement by which metal was to be sold at a minimum rate of £165 per ton, and then only 5 per cent. for every completed month when the price was above £165 per ton with increasing ratios at higher values, was liquidated in the latter half of 1933, and the old International Tin Committee's agreement, which had still eight months to run, was terminated at the end of 1933 and supplanted by a new one which came into force on 1st January, 1934 for three years. This new agreement started with an allowance of 40 per cent. of a new scale of basic tonnages accepted by each of the signatory countries.

Burma during this period resisted all the advances of the International Tin Committee to co-operate in their activities and the

total output of Burmese tin concentrates rose steadily from 3,694·2 tons valued at Rs. 58,54,387 in 1929 to a maximum of 4,503·9 tons valued at Rs. 64,37,656 in 1933, an average of 4,039·5 tons valued at Rs. 47,71,388.

Burma production.

Table 111 shows how this compares with the three former periods :—

TABLE 111.—*Growth of Tin-ore production in Burma.*

——	Average annual output concentrates.	Average annual value.
	Tons.	Rs.
1929-1933	4,039·5	47,71,388
1924-1928	2,802	47,43,601
1919-1923	1,854	23,32,747
1914-1918	483	7,62,600

Owing to the big increase in production, the table gives the impression that conditions were not unfavourable to the industry in Burma during the quinquennium. This was not so, however, as the increase was due to the big concerns working in the Tavoy district whose influence on increased output was predicted in the last quinquennial review and also to the Mawchi mines in the Southern Shan States, whose mill operated for nearly four years in the present quinquennium as against only two years in the last. Conditions in the industry, especially among the small producers, were so bad that with effect from 1st October, 1930, the Government of Burma suspended the collection of dead[1] and surface rents on mining leases for tin and wolfram until further orders; they further ordered the suspension of forest royalty, which had been assessed in a lump sum and was payable in annual instalments, and required only payment of royalty in respect of timber actually used. These orders were not rescinded during the period under review.

[1] 'Dead rent' is a fixed acreage fee assessed by Government on all land issued under mining lease and for all practical purposes may be regarded as 'a minimum royalty fee' as the licensee pays royalty at a fixed percentage on the sale value on the surface of the dressed ore or metal mined or the 'dead rent' whichever is greater. It ensures active mining operations on the lease and acts as a deterrent to the holding of mining leases purely for speculative purposes.

TABLE 112.—*Quantity and Value of Tin-ore produced in India during 1929 to 1933.*

Year.	Amherst.		Mergui.		(a) Southern Shan States.		Tavoy.		Thaton.		Total.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
1929 . .	40·2	*60,136*	1,184·0	*20,09,782*	281·0	*4,45,385*	2,170·9	*33,11,751*	18·1	*27,333*	3,694·2	*58,54,387*
1930 . .	42·6	*49,566*	787·6	*8,89,990*	923·0	*9,83,918*	2,181·5	*22,72,502*	9·2	*9,589*	3,943·9	*42,05,565*
1931 . .	17·0	*17,683*	497·4	*3,96,304*	1,339·0	*11,05,336*	2,044·8	*16,96,213*	1·0	*500*	3,899·2	*32,16,036*
1932 . .	19·2	*22,712*	598·0	*5,44,532*	1,189·0	*11,85,433*	2,349·6	*23,89,826*	0·9	*996*	4,156·7	*41,43,299*
1933 . .	23·0	*33,906*	978·7	*12,71,204*	1,282·0	*18,31,978*	2,215·8	*32,93,988*	4·4	*6,580*	4,503·9	*64,37,656*
Average .	*28·4*	*36,801*	*809·1*	*10,22,322*	*1,002·8*	*11,10,410*	*2,192·5*	*25,92,856*	*6·7*	*8,999*	*4,039·5*	*47,71,388*

(*a*) Estimated and revised.

Table 112 shows the quantity and value of tin-ore produced in India, district by district, during the period 1929-1933. Compared with the figures for the previous period the rise in the almost negligible production of Amherst shows the gradual extension of mining operations northwards from the known tin-bearing areas of Tavoy; the Mergui figures of 809·1 tons differ little from the average annual production of 795·6 tons during the period 1924-1928, but would have been much greater had the only large producer in the district, the Thabawleik Tin Mining Co., Ltd., not suspended operations during the two worst years of the depression. In the Southern Shan States the greatest increase was registered. This was due to the activities of the Mawchi Mines Ltd., the only producer. Idle for the first two years of the last quinquennium, after two years of production—1926 and 1927, when substantial returns were shown—milling was again suspended during development operations and did not recommence until March, 1930. Thus the returns for the quinquennium under review refer to not quite four years of actual production whilst those of the previous one refer to two years only. The developments that were carried out during the stoppage certainly increased the productive capacity of the property and had output been increased to potential capacity a still larger increase would undoubtedly have been registered.

The quinquennium opened in Tavoy with a greatly enhanced production owing to the development of mining operations on a big scale. During 1929 and 1930 this increase was helped by the more remunerative prices that wolfram was bringing, as two of the four large producers in Tavoy, companies who contribute over 80 per cent. of the district's annual output, produce a mixed concentrate of tin and wolfram in practically equal proportions. During the remaining period, at least one of the companies producing pure tin concentrates was working up to standard capacity as they had only just got going on a large scale when the quinquennium began.

From 1929, when the world's greatest output of tin-ore was recorded, until 1933, when the depression in the industry had been surmounted, Burma increased her production by 910 tons of ore or in terms of tin, approximately 637 tons. This expansion is all accounted for by the single Mawchi mine, the production of which in 1929 was, owing to the mill being out of operation, only 281 tons of tin-ore and in 1933, 1,282 tons. The Mawchi mine,

it may be mentioned, is situated in an independent native state and does not come under the administration of British India.

TABLE 113.—*Consumption of foreign Block Tin in India.*

Year.	Imports.		Re-exports.	Consumption.
	Quantity.	Value.		
	Cwts.	*Rs.*	Cwts.	Cwts.
1929 . . .	55,358	*80,95,974*	542	54,816
1930 . . .	56,739	*62,33,676*	1,581	55,158
1931 . . .	41,969	*36,28,556*	329	41,640
1932 . . .	49,279	*47,50,341*	706	48,573
1933 . . .	41,655	*52,96,454*	829	40,826
Average .	*49,000*	*56,01,000*	*797*	*48,203*

The consumption of metallic tin imported in the unwrought form of blocks, ingots, bars and slabs, which had hitherto shown a gradual increase, fell slightly during the period 1929-1933. The average annual quantity amounted to 2,450 tons valued at Rs. 56,01,000 compared with 2,716 tons valued at Rs. 95,35,073 for the previous quinquennium. Ninety-seven per cent. of this metal came from the Straits Settlements. A point which may be emphasised here is that as the annual production of tin-ore in British India (this excludes Mawchi, which is in an independent native state) when transposed into terms of metal was only 2,126 tons during the period under review, the production of tin-ore in British India has not yet caught up to the country's absorption capacity in terms of block tin alone and it is perhaps legitimate to enquire whether it would not be profitable to smelt tin-ore on a large scale in Burma instead of exporting it abroad and then importing the metal again into the Indian Empire, particularly in a country where some new industries have been given protection in the form of import tariffs on their products. Small amounts of block tin are produced in native furnaces in Mergui, Palaw and

Bokpyin in the Mergui district from time to time but show recovery values from 3 to 4 per cent. below those of Straits smelters.

Mergui district.

During the progress of the systematic geological survey of the Mergui district, tourmaline-muscovite-pegmatites, locally carrying cassiterite, but never wolfram, have been found in various places cutting both the granites and sedimentary rocks into which they are intruded.

Full details of these will be found in a memoir on the geology of the Mergui district by the late Rao Bahadur Sethu Rama Rau.[1]

Both cassiterite and wolfram display a tendency to be deposited in thin stringers or leaders, and little veinlets, half-an-inch or so in thickness, are often found which reproduce the internal structures of large veins. Such stringers are often excessively rich for their size and sometimes certain very rich patches of ore. When such veinlets occur in close association in soft ground, they may form a valuable source of these ores. Much of the so-called 'alluvial' (eluvial) concentrate won by sluicing residual or decomposed rock is derived from the very numerous stringers and mineralised cracks penetrating such rock both in Mergui and Tavoy.

The size of the grains of Burmese stream tin depends entirely on the distance the mineral has travelled from its original home. In the upper parts of the valleys, where little classification of the river deposits has taken place and where there is still much unsorted detrital matter, individual crystals of about the size of a coffee bean, with their edges rounded, can be picked out of the finer material. Further down stream, smaller rather angular fragments are characteristic, but in the real alluvial sands and gravels the fine concentrated ore develops a rounded form often recalling the appearance of gunpowder. Here it is associated with magnetite, ilmenite, topaz, garnet and zircon, and sometimes with minute amounts of monazite and gold.

Attention has been drawn in earlier reports to the Maliwun vein deposits. Originally worked by the Chinese and later by European companies, the mine was lavishly equipped with machinery, but it was never able to pay, and the abandoned hydro-electric generators with mill, compressor, hydraulicing plant and electric trams quickly rusted in the jungle, while a gang of Chinese tributors returned to their former practices. The quartz veins and greisen

[1] *Mem. Geol. Surv. Ind.*, LV, Pt. 1, (1930).

bands at Maliwun are in granite very close to its margin with the Mergui sediments, and they contain much white mica and some pyrite, chalcopyrite and arsenopyrite. Tourmaline has also been recorded.

The question of searching beneath the sea for tin-ore along the Tenasserim coast received some attention during 1924-1928 and concessions for this purpose were granted by the Government of Burma along the shores of the southern part of the Mergui district. There is little doubt that alluvial deposits brought down by rivers traversing stanniferous rocks, and spread over the sea floor in the vicinity of their mouths, must contain a certain proportion of cassiterite. Indeed submarine tin deposits have been profitably worked in Java and other eastern countries, but up to the present they have not been located in Burmese waters.

The large scale dredging operations of the Thabawleik Tin Dredging Company Ltd., which commenced in 1926 added appreciably to the output of tin concentrates from the Mergui district until 1929. Thereafter followed a period of heavy restriction; the dredger was laid up and was not used again until 1933, when higher prices for tin prevailed. The effect of this stoppage is clearly reflected on the output of tin-ore from Mergui during the period (*see* Table 112).

Tavoy district.

Geological conditions in Tavoy district are much the same as those in Mergui. Granite intruded into an ancient sedimentary series forms the cores of the mountain ranges; quartz veins and pegmatites carrying wolfram, cassiterite, molybdenite, bismuth, bismuthinite, and a large variety of sulphides, cut through them both. These minerals occur also in the eluvial deposits of the hill-sides, where veins are undergoing degradation, and in the coarse unsorted debris of clay, rotten rock and boulders, which tend to accumulate at the heads of the flatter valleys. Cassiterite is found too in the water-sorted alluvial deposits, the gravels and sands of the lower portions of the streams.

Though Tavoy is primarily a wolfram-bearing region, there are areas within its boundaries which are richer in cassiterite than the rest and it is from these and from the gradual extension of dredging operations that increased production has been and will be recorded.

The *Tavoy Tin Dredging Corporation, Ltd.*, whose prosperous career was commented upon in the last Quinquennial Review, continued its activities in the Hindu Chaung area, but did not work to full capacity throughout the period under review. In 1929, 567½ tons of concentrates were produced; in 1930 production was cut down to 339¾ tons to comply with the voluntary restriction scheme of the Tin Producers Association and in the same year an amalgamation on a basis of exchange of shares was carried out between the Tavoy Tin Dredging Corporation, the Northern Tavoy Tin Dredging Coy., Ltd., the Theindaw Tin Dredging Coy., Ltd., and the Thingandon Tin Dredging Coy., Ltd., in order to facilitate the working of several areas as a comprehensive unit under one administration. This enabled the newly constituted corporation to suspend extraction on the areas least economical to work and concentrate on areas where costs could be reduced and maintained at the lowest possible level.

In 1931, in spite of voluntary restriction in the early part of year, first three and later four of the six dredgers being closed down, production for the year for the new corporation was 739 tons. During the following year 2,011 acres of dredgeable alluvium situated between the town of Tavoy and the Corporation's holdings at Kyaukmedaung were purchased from the Kamounghla Tavoy Tin Ltd., thus bringing the total area held by the Corporation to 10,264½ acres of which only 851 acres had then been worked out. During 1933, 92 acres were dredged, and over 3¾ million cubic yards of alluvium treated to give a total output of 696 tons of tin concentrates, a further 80½ tons being won by tribute.

We are indebted to the General Managers of the Consolidated Tin Mines of Burma, Ltd., the Anglo Burma Tin Coy., Ltd., and the Kanbauk Mines Ltd., for the following notes on their properties during the period under review.

Consolidated Tin Mines of Burma, Ltd.

This company holds an area of approximately 11,200 acres under mining leases in the Tavoy district, Tenasserim Division of Lower Burma. The principal mines worked are as follows:—

(*a*) *Hermyingyi.* Situated about 24 miles from Tavoy on a road which branches off the Siam road at Pagaye (10th mile) in a north-easterly direction. This mine comprises two hills rising to 1,100 and 1,600 feet respectively and

traversed by a series of veins running in a northerly direction. The veins are narrow in general and approximately vertical. They are exploited by adits and the associated detrital surface deposits by monitors during the wet season. The veins are associated with the contact between the granite and the Mergui series of schists, etc.

(*b*) *Taungpila.* Situated on a branch of the same road at about 24 miles from Tavoy and 2 miles to the south-east of Hermyingyi. A series of low hills traversed by greisen veins, associated with the contact. The deposits are worked both by monitors supplied from a large reservoir and pipe line and by adits.

(*c*) *Bwabin.* Situated on a branch of the Siam road near Wagon village about 25 miles from Tavoy. Veins and detritals worked by monitors and adits.

(*d*) *Wagon.* The area intervening between Bwabin and Taungpila. Scattered veins and detritals are worked in this area.

(*e*) *Kalonta.* A detached area on a branch road from the 16th mile on the Tavoy-Ye road to the village of Thitkado. The mine is situated at about 24 miles from Tavoy. Veins in granite associated with the contact are worked by hydraulicing and by shafts or adits.

Output of mixed concentrates.

This was as follows :—

Period.	Tons produced.	Assay value.		
		Sn. Per cent.	WO_3. per cent.	Total.
1929-30	1,366	33·2	33·1	66·3
1930-31	1,556	33·3	33·3	66·6
1931-32	1,329	35·7	32·2	67·9
1932-33	1,144	32·9	35·2	68·1

Development and equipment.

1929-30.—The following work was done :—

(1) The installation of machine drills at the Hermyingyi and Taungpila mines.

(2) The installation of 12,500 feet of 3 feet 6 inches by 2 feet iron fluming at the Hermyingyi mine.

(3) The installation of pumping plant with monitors for sluicing ground at the Hermyingyi mine.

(4) The installation of a ropeway for the excavation of gravel at the Hermyingyi mine.

(5) The building of a concrete dam 33 feet high for conserving water at the Taungpila mine.

(6) The installation of 6,000 feet of 36 inches by 27 inches flume and 12,500 feet of 24 inches to 18 inches pipe-line for tapping a new source of water at the Kalonta mine.

(7) The installation of 7,500 feet of 18-inch pipe to tap a new supply of water at the Wagon South mine.

(8) The installation of additional monitors at all the principal mines with branch piping from mains for their water supply, making the total number of monitors over 80.

(9) The building of additional housing accommodation on the mines, for mine staffs and coolies.

(10) The extension of the magnetic separator plant to deal with the increased output of mixed concentrates, and its reorganisation on the lines indicated by recent research work.

(11) The installation of hydro-electric generating plants for supplying electric light to the monitor faces at the Kalonta and Taungpila mines.

(12) The installation of crude oil storage tanks to enable oil to be purchased in large quantities in order to reduce its cost.

Additions were made to the separator at Tavoy which resulted in its capacity being doubled and efficiency improved.

On lodes, a distance of 3,350 feet was driven.

1930-31, 1931-32.—Owing to the state of the metal market no material additions were made to the equipment and no development work was done. Certain units were placed temporarily out of commission, pending an improvement in metal prices.

1932-33.—The sum of £1,200 was expended on development of veins but this was charged to working costs.

A small crushing unit was erected at Kalonta mine. No additions were made to plant.

Working Costs.—The all-in cost of mixed concentrate including mining, separating, smelting, realisation and overhead charges in Burma and London were as follows:—

Period.	All-in cost per ton.			Average price realised per ton.		
	£	*s.*	*d.*	£	*s.*	*d.*
1929-30	100	4	11	103	4	7
1930-31	74	14	8	63	14	3
1931-32	61	4	7	63	18	2
1932-33	62	19	1	73	12	8

Anglo Burma Tin Company, Limited.

Heinda Mine, Tavoy district.—The following are the annual outputs of tin-ore from the company's properties for the years covering the period under review:—

	Tons.
1928-29	151
1929-30	239
1930-31	320
1931-32	368
1932-33	438
1933-34	374

The decrease in production during the last year was due to a lesser cubic yardage treated owing (1) to a tough clay encountered on the flats, (2) a lower effective pressure at the monitors owing to a higher operating level on the hill-section. Prospecting operations during the period have proved additional payable tin-bearing ground and ore reserves have either been maintained or increased as a result of each year's operations.

The recovery at Heinda was 1·21 lbs. of tin-ore per cubic yard in 1932-33 and 1·34 lbs. in 1933-34, but the average working costs in the latter year were 10·03 pence per cubic yard compared with 7·57 pence in 1932-33 for the reasons given above.

The average gross price received from the smelters per ton of tin-ore in 1933-34 was £154-11-10 compared with £108-17-0 for the previous year.

Towards the close of the period under review the company purchased two leases at Shanthe in the Palaw district, of an approximate area of 1,277 acres. Six hundred tons of payable tin-ore have been proved on this property and further testing is likely to add to this figure.

Tribute operations were profitably continued in the Thabawleik area of the Mergui district throughout the quinquennium.

Kanbauk Mines, Limited.

The output of concentrates won from the Kanbauk mine for the years 1929 to 1933 inclusive together with the products derived therefrom after magnetic separation and classification are as follows :—

Products.

Year.	Output.	Tin concentrates.	Wolfram concentrates.	Losses.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons.
1929	503·7	279·8	220·1	3·8	503·7
1930	615·0	301·6	304·0	9·4	615·0
1931	252·8	134·2	116·4	2·2	252·8
1932	367·5	215·3	151·0	1·2	367·5
1933	402·4	221·8	179·9	0·7	402·4

During the slump years, 1931 and onwards, only such sections of the mine as could be operated most cheaply were worked. This of course, is reflected in the annual production figures shown above.

Amherst district.

The geological survey of the Amherst district has been continued intermittently during the period and the metamorphic aureoles around the intrusions of the local granites have been proved to carry tourmaline and veins of tourmaline-micropegmatite, which in places bear quartz stringers with cassiterite. In addition to the localities mentioned in the previous report, occurrences of tin-ore have been sporadically worked in lateritic talus deposits at Thetkaw and at Sakangyi while a small pegmatite vein traversing shales and sandstones and containing black cassiterite is known at Kunhnitkway.

In the last Quinquennial Review reference was made to the reconstruction that was going on at the Mawchi mines at the end of the 1924-1928 period, milling being stopped during development. By the end of June 1929, 135,879 tons of ore with an average assay value of 4·26 per cent. combined tin and wolfram had been proved above the level of No. 1 main cross-cut adit, and in February, 1930 mining and milling were resumed, it being estimated that there was then about 3 years' supply of ore available above No. 1 level, whilst the No. 2 main cross-cut adit (150 feet below No. 1) had been completed. In view of the over-production from which the tin industry was then suffering the company did not attempt to expand their scale of operations, but at the same time maintained a steady output of about 3,000 tons of mixed tin and wolfram concentrates per annum. At the end of 1932 the ore reserves at the mine were estimated at only 69,487 tons, but as several new lodes showing encouraging values had been discovered, it was anticipated that these reserves would be greatly increased in the near future when funds became available for development work. At a meeting held in July, 1933 a financial reconstruction of the company was agreed to by shareholders. More capital was acquired, debts were paid off and with the rising prices of both wolfram and tin all was ready for a more successful period in the company's history. The chairman at the meeting estimated that, taking tin at £200 per ton and wolfram at 10*s*. per unit, every £10 rise in the price of tin should increase the profits of the company by approximately £6,000 per annum and every shilling rise in the price of wolfram should increase their profits by £3,000 per annum.

Southern Shan States.

Ore reserves at 31st December 1933, were reported to be 63,539 tons averaging 4·34 per cent. combined tin and wolfram.

Cassiterite is known to occur in the Hazaribagh district of Bihar and Orissa and insignificant quantities of the ore have been returned from this locality in previous periods. They are believed to have been derived from the Nurunga deposits where the mineral is found in a cassiterite-granulite. Both this and the further occurrences of Pihra and Domchanch in the same district, though of some scientific interest, possess no economic importance.

Indian occurrences.

Tungsten.

[E. L. G. CLEGG.]

History.

The earlier records of the occurrence of wolfram, a tungstate of iron and manganese, in Burma, date back to the forties of the last century and refer mainly to the efforts of misguided enthusiasts to extract tin from the mineral. These early experiments were completely forgotten in the course of time and it was not until 1908 that wolfram was rediscovered by a member of the Geological Survey of India. From that time onwards the industry slowly developed through many vicissitudes until Burma headed the list of the world's producers, a position which she occupied in 1914 when the world war broke out and found the British Empire dependent upon Germany for supplies of tungsten -the metal which is so essential for martial operations. The measures which were taken to deal with this unprecedented situation and the degree of success which they attained have been described in earlier reviews. It is only necessary to recall here that the average annual output for the years 1914-1918 was 3,473 tons. A period of stagnation followed and the next quinquennial period (1919-1923) only registered an average of 1,726 tons per annum, valued at Rs. 15,80,725, for reasons discussed in its review. During the quinquennium 1924-1928, tungsten mining in Burma went from bad to worse and the average annual output for the period was only 955 tons, valued at Rs. 4,86,752, most of which was probably obtained as a by-product in mining operations conducted primarily for the recovery of tin-ore.

During the period 1929-1933, a revival in the wolfram industry in Burma in 1929 and 1930 was followed by a slight set-back in 1931 and 1932 and a resuscitation in 1933. The average annual output of 2354·6 tons valued at Rs. 13,58,206 was a great increase on that of the previous quinquennium and the best recorded since the war period of 1914-1918.

In a previous review, reference was made to the extraordinary history of China as a wolfram-producing country, by which she rose to the first place of the world's list. The world's production of tungsten-ores to-day may be taken as approximately half that of the war period, but China still dominates the situation with a production far in excess of that of any other country, in spite of her

own political upheavals. Over 95 per cent. of the world's output of tungsten-ores is absorbed by the steel industry and in 1929, the large production of steel was responsible for the greater activity of the tungsten market. The year opened with the price of tungsten standing at about 20*s.* per unit of 1 per cent. WO_3 (65 per cent. WO_3); it rose rapidly to over 40*s.* per unit in August and although it experienced a slight set-back thereafter, the average for the year was about 29*s.* per unit. The world's production was estimated at 17,000 tons to which Burma contributed 1,397·2 tons. Towards the close of the year, a co-operative organisation for the purchase of tungsten-ore was set up by the European producers of tungsten-steel.

In 1930 in spite of the world-wide depression in most metals, the tungsten industry was relatively active during the first half of the year but fell away in the second half. The price declined from 34*s.* per unit at the beginning of the year to 15*s.* to 16*s.* at the end, the average being about 22*s.* per unit. The world's production, estimated at about 16,000 tons (Burma 2,778·5 tons), exceeded consumption by about 1,000 tons and 1931 saw the industry back into its former moribund condition. The average price for the year was 13*s.* to 14*s.* per unit; world's production was estimated at 12,500 tons (Burma 2603·7 tons) and mines in Burma producing pure wolfram concentrates, which had been reopened owing to the high prices prevailing in 1929, and the first half of 1930, again closed down. The almost complete collapse of the steel industry in 1932 was responsible for a reduction in the world's production of tungsten-ores to about 6,000 tons—less than half the production of a normal year. China was responsible for the greater part of this decline. The average price for the year was about 12*s.* per unit, the lowest price 10*s.* 6*d.* to 11*s.* per unit being quoted at the close of the year. The depression in the industry continued into 1933, but the marked improvement in the steel industry in the spring of that year led to a big demand for tungsten and the price rose rapidly from 10*s.* 6*d.* to 11*s.* per unit in June to 26*s.* to 27*s.* at the end of the year. This revival in the industry continued throughout 1934. Towards the end of 1933, the Canton Government succeeded in establishing a strong monopoly regulating both price and production of tungsten-ores from the Chinese mines. Any efforts on the part of China to regulate supply and keep up the price of wolfram are particularly welcome as it has been the uncontrolled supply of tungsten from the extensive and easily accessible deposits of China which has made the

mining of tungsten-ores such a speculative and on the whole profitless undertaking in other producing countries since the war.

Production.

Table 114 shows the production of tungsten in Burma by districts and although, in quantity of output, Tavoy has now to take second place to the Southern Shan States it is to Tavoy that one must look for increased production should the revival in the tungsten industry be of any permanence. As can be seen from the table, the output from the Southern Shan States shows no reactions to the price of the ore at all. This is of course due to the whole of the output coming from the one property (Mawchi) where the ore won is a mixed concentrate of tin, wolfram and scheelite. In 1929 and for the first two months of 1930, no milling was done by the Mawchi Mines, Ltd., the production being obtained from local tributors; thereafter milling was continued, although not, according to the company, to maximum capacity.

In Tavoy, the effects of the high prices of 1929 and 1930 are well brought out in the table. That no such effect is visible in 1933 is due to the lag which always takes place between higher prices and greater production, especially where this extra production, as in Tavoy, is derived from small properties which have become derelict during a slump period. The average production from Tavoy during the previous quinquennium was just under 700 tons and this may be taken as the average amount of wolfram won incidentally in the mining of tin-ore in that district, although with the development of the tin industry this is likely to rise. It is unlikely therefore in future, provided the price of tin remains fairly stable at its present remunerative rate, that the production of tungsten-ore in Burma will drop below 2,000 tons per annum; provided the price of tungsten also keeps up, annual outputs of 3,000 to 4,000 tons of wolfram may be expected.

Occurrence in Burma.

Quartz veins containing wolfram have been found at intervals over a distance of 750 miles in Burma from the Yengan and Mawnang States of the Southern Shan States through the districts of Kyaukse, Yamethin, the State of Karenni, Thaton, Amherst, Tavoy and Mergui. In all these localities the wolfram- and cassiterite-bearing veins are closely associated with a biotite boss-granite, which forms the core of the ranges of the Indo-Malayan mountain system stretching further to the

TABLE 114.—*Quantity and value of Tungsten-ore produced in India during the years 1929 to 1933.*

Year.	MERGUI.		(a) SOUTHERN SHAN STATES.		TAVOY.		THATON.		TOTAL.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
1929 . .	50·4	*21,990*	329·0	*3,70,125*	1,010·8	*11,75,240*	7·0	*4,368*	1,397·2	*15,71,723*
1930 . .	74·7	*35,393*	1,270·0	*9,37,260*	1,432·8	*10,78,054*	1·0	*500*	2,778·5	*20,51,207*
1931 . .	98·3	*28,688*	1,635·0	*6,40,920*	870·4	*3,51,609*	..	..	2,603·7	*10,21,217*
1932 . .	96·7	*33,253*	1,542·0	*5,36,616*	751·4	*2,61,840*	..	..	2,390·1	*8,31,709*
1933 . .	73·5	*25,978*	1,768·0	*8,92,840*	762·1	*3,96,354*	..	..	2,603·6	*13,15,172*
Average .	78·7	*29,060*	1,308·8	*6,75,552*	965·5	*6,52,619*	1·6	*974*	2,354·6	*13,58,206*

(a) Estimated and revised.

south through western Siam to the Malay Peninsula. The granite is intruded into a series of hardened and crushed shales, slates, argillites and agglomerates with greatly subordinate quartzites, limestones and conglomerates known as the Mergui series. These rocks are of unknown age, and are characterised by a monotonous uniformity of type over great areas and over an immensely thick mass of strata. In its typical exposures, though it varies considerably in texture, the granite is extraordinarily uniform in composition. It contains abundant quartz. both orthoclase and acid plagioclase, while the mica is usually biotite. Towards the peripheries of the intrusions, the rock becomes finer-grained than the porphyritic and coarse varieties nearer the centres; biotite is scarcer, and muscovite takes its place. Hornblende is rare and accessory minerals are very uncommon, pseudo-foliation is often developed near the contacts, and has led some observers to mistake portions of the rock for gneiss.

Both wolfram and cassiterite occur very sparingly as accessory minerals in the granite; they are also found in aplite and pegmatite veins traversing it and in the greisens, the narrow bands of quartz-mica rock formed by the alteration of the granite adjoining the true quartz veins. These modes of occurrence are of more theoretical interest than practical importance, and, with the exception of the surface deposits, quartz veins furnish the great bulk of the concentrates from Burma. Mineral-bearing quartz veins are found either in the granite, penetrating its contact with the sedimentary rocks, or enclosed within the latter rocks themselves at no great distance from the granite. The veins were formed by the infilling of fissures and often occur in parallel groups of over-lapping lenses. The lenses themselves are often irregular. thinning out and thickening again, splitting and then re-uniting. There is every variation from great veins traceable for miles on the surface to mere stringers. The general strike follows that of the main mountain trend, and is N.-S. to N.E.-S.W. Dips are usually high.

In different parts of Burma the mineral associates of wolfram are not the same. Beryl has only been found at Byingyi in the Yamethin district. Tourmaline is common at Mawchi in Karenni, in the Thaton district, and in parts of Mergui; in Tavoy it is unknown in conjunction with wolfram or cassiterite. Here, in addition to these minerals, the quartz veins carry mica (practically always), fluorite (often), molybdenite (sometimes), pyrrhotite (in some cases),

galena (rare), zinc blende (rare), arsenopyrite (rare), native bismuth (rare), bismuthinite (rare), and topaz (in one case only). In the Tavoy district alone there were over 100 producing concessions in 1918, which ranged from shallow workings operated by primitive Chinese methods to deep mines, fully equipped with the most modern concentrating plants. The largest mines were Hermingyi, Kanbauk, Widnes, Pagaye, Paungdaw, Taungpila and Kalonta.[1] Some of these are still producers although in times of depression in the wolfram industry cassiterite becomes their primary product, (*see* Tin).

The chief wolfram deposits of the Mergui district are near Palauk in the north, and at Tagu near the Great Tenasserim river, some 70 miles from its mouth. The veins of the Tagu area are remarkable for their large size, varying from 3 to 15 feet in thickness; they are all in granite, and carry arsenopyrite and chalcopyrite. The veins of the Maliwun area, too, in the extreme south of Mergui district are in granite, but in the Palauk area the veins occur in both granite and sedimentary rocks.

The wolfram-bearing veins of Thaton are in two well-marked series -one in granite, and the other in the sandstones of the long mountain ridge which runs parallel to the coast through this district. They differ markedly from those of Tavoy, in that they carry tourmaline. Four parallel veins, only a few inches thick, have been traced for the unusual distance of 2½ miles.

The well-known Mawchi mine is situated in the southern portion of the Bawlake State of Karenni. It possesses at least ten important veins varying from 2½ to 5 feet in thickness, which are all in granite, (*see* Tin).

The wolfram-bearing area of the Yamethin district is situated close to the summit of Byingyi, a peak which rises 6,254 feet above sea-level on the borders of Yamethin and the Loi Long State. The veins are in granite, and carry wolfram, molybdenite and beryl.

In the concessions of the Myelat division of the Southern Shan States, granites, clay slates and quartzites are penetrated by veins carrying wolfram, molybdenite, and copper and iron compounds.[2]

[1] *See* J. Coggin Brown and A. M. Heron, 'The Ore Deposits of Tavoy', *Mem. Geol. Surv. Ind.*, XLIV, Pt. 2, (1923).

[2] For fuller details *see*; 'The Distribution of the Ores of Tungsten and Tin in Burma', by J. Coggin Brown and A. M. Heron, *Rec. Geol. Surv. Ind.*, L, pp. 117-129, (1919), and 'A geographical classification of the Mineral Deposits of Burma', by J. Coggin Brown, *op. cit.*, LVI, pp. 65-108.

Although further discussion is impossible here, it is hoped that the brief notes given will demonstrate clearly how closely all the wolfram and cassiterite deposits of Burma are associated with the intrusive granite already mentioned. It is believed that the deposits were formed partially under conditions closely allied to strictly magmatic ones, and were also produced by processes* in which gaseous agencies, including compounds of fluorine and sulphur, to some extent played a part, and, in rare cases, by hydrothermal reactions which followed as a consequence of the former ones. Thus, the whole process of mineral vein formation, associated with this great granite chain, appears to be a direct sequence of processes of differentiation or fractional crystallisation, through a varying series of phases, influenced by local conditions and included in the original magma by decreasing temperature.

Indian occurrences.

No output of wolfram was registered either from the Singhbhum district of Bihar and Orissa or from Degana (Jodhpur) in Rajputana during the period under review.

Zinc.

[E. L. G. CLEGG.]

Zinc concentrates are produced at the milling plant of the Burma Corporation, Ltd., at Namtu, Northern Shan States. The zinc mineral is sphalerite and occurs as an intimate associate of the galena at the Bawdwin mine, (*see* Lead).

Production.

The origin of the zinc industry in India is of comparatively recent date and the progress made has been very substantial. During the quinquennial period 1909-1913, no production of zinc was recorded; in the period 1914-1918 exports were returned as 11,973·6 tons up to 1916 and *nil* thereafter; the period 1919-1923 showed a steady rise in exports from a quarter of a ton in 1919 to 18,061 tons in 1922 and then a set-back to 2,062 tons in 1923; in the quinquennium 1924-1928 there was a marked and rapid increase in the output of zinc concentrates from 18,650 tons in 1924 to 64,122 tons in 1928, the average for the period being 41,340 tons valued at Rs. 50,55,160. In the quinquennium under review the average production, despite the vicissitudes

through which the industry has passed, again shows a rise to 54,685 tons, but the value at Rs. 28,73,823 shows a serious decline. (*see* Table 115.)

TABLE 115.—*Quantity and value of Zinc concentrates produced during the years 1929 to 1933.*

—	Tons.	Value.	
		Rupees.	Sterling.
1929	58,435	*54,80,034*	(*a*) 408,958
1930	57,620	*25,73,309*	(*b*) 190,615
1931	51,455	*17,23,528*	(*b*) 127,669
1932	44,484	*15,09,298*	(*c*) 113,481
1933	61,432	*30,82,944*	(*c*) 231,800
TOTAL .	*273,426*	*1,43,69,113*	1,072,523
Average 1929-33 .	*54,686*	*28,73,823*	*214,506*

(*a*) £1=Rs. 13·4. (*b*) £1=Rs. 13·5. (*c*) £1=Rs. 13·3.

World's production and prices.

Reference was made in the previous review to the rapid and steady growth in the world's output of zinc with a result that over-production had become a feature of the industry. World production in 1921 was 439,648 tons; in 1924 the total had reached 1,002,538 tons; in 1927, 1,305,371 tons and in 1928, 1,395,718 tons. Successful efforts to arrive at some agreement among zinc producers on a policy aiming at a stabilisation of the market were made in 1928, and it was agreed to restrict output when zinc fell below £27 per ton. In 1929 there was a further increase in the world's production to 1,438,662 tons, Burma's contribution being 58.435 tons, 5,687

tons less than that of the maximum of 1928 and the average price of the metal fell from £25-5-5 in 1928 to £24-17-8 in 1929. Restriction varying from 5 to 10 per cent. had been attempted but the world depression which had set in reduced consumption to such an extent that towards the end of the year the price fell rapidly and continued to fall throughout the whole of 1930. The lowest price registered during this latter year was £13-5 and the average £16-16-9. Meanwhile the world's output for 1930 at 1,413,091 tons (Burma 57,620 tons) showed very little decrease, and an inability to reconcile their various interests led to the abandonment for the time being of any united scheme of restriction among producers.

A further rapid fall in the price of spelter to £9-18-9 in June, 1931 led to a reconciliation among producers and the formation in July of an International Zinc Cartel, which immediately imposed a 45 per cent. restriction on output. This restriction was increased to 50 per cent. in December and world production was brought down to 1,013,000 tons (Burma 51,455 tons) whilst the price towards the end of the year had recovered to £14-7-6, the average being £12-9. In August, 1932, restriction was further increased to 55 per cent. and the world's annual production was brought down to 788,000 tons (Burma 44,484 tons) with a consequent lowering of stocks and a small rise in average price to £13-14.

In January, 1933 there was a break up of the Cartel, but an immediate set-back in price led to its re-formation forthwith and the year saw a further decrease in stocks and rise in average price to £15-15 despite a rise in world's production to 996,000 tons. In the same year Burma recorded a big rise in output to 61,432 tons, the second best annual production yet attained. This was due to the increase in the zinc content of the ore mined and the larger tonnage milled. On 19th December, 1932, the Indian Legislative Assembly passed an agreement with reference to the Ottawa agreement, based on the principle that the first place in market consumption in India for galvanised sheets (India is the largest market for galvanised sheets) is reserved for the Indian output of sheets. The second place is reserved for British sheets produced from Indian intermediate materials. Only consumption not covered by these two can be supplied by the United Kingdom regardless of the intermediate materials used. This agreement took effect from 1st January, 1933. As the Burma Corporation are the only producers of zinc concentrates in India this appears to give them a monopoly

of the zinc output destined for the production of galvanized sheets for the Indian market and no doubt accounts for the big increase in the ore milled during 1933.

Imports.

The value of the market in India for wholly or partly finished zinc articles may be judged from the following figures showing the imports of zinc into India. The average imports for the post-war period 1924-1928 were 8,241 tons valued at Rs. 39,45,234, for the period 1929 to 1932 they were 11,442 tons valued at Rs. 32,57,280, whilst for the years 1933 and 1934, during which the passing of the agreement referred to above was in operation, they were 16,063 tons valued at Rs. 37,49,873. These figures do not include zinc imported in the form of its compounds, zinc whites or in alloys such as brass under which headings imports must be quite considerable.

Zircon.

[L. L. FERMOR.]

Zircon, orthosilicate of zirconium, is a common accessory mineral in many granites and gneisses, and as such it is often found accompanying gravels and sands derived from such rocks. It is a constant constituent of the beach sands of Travancore. Fine crystals are to be obtained from some of the pegmatites of the Travancore State. Zircon is found in the nepheline-syenites near Kangayam, Coimbatore district; in pegmatites at Kadavur, Trichinopoly district, and near Domchanch, Hazaribagh district; and in the Seitur graphite mine, Ramnad, Madras Presidency. Large clusters of crystals of a dark brown colour have been obtained from Abraki Pahar, Gaya district, Bihar and Orissa. A hydrated form resembling cyrtolite containing a small percentage of uranium is associated with samarskite in the Nellore district, Madras.

Zircon is recovered from the Travancore beach sands by the Travancore Minerals Company, Limited, Messrs. Hopkin and Williams, Ltd., and F. X. Pereira & Sons, and is exported to the United Kingdom, Germany, United States of America and Austria (since 1933). The output during the present quinquennial period has averaged 827 tons valued at £6,190 against 759 tons valued at £4,542 in the period 1924-1928, (*see* Table 116).

TABLE 116.—*Production of Zircon in Travancore during the years 1929 to 1933.*

Year.	Tons.	*Value.*
		£
1929	1,473	*10,805*
1930	640	*4,991*
1931	855	*7,972*
1932	491	*3,805*
1933	675	(*a*) *3,375*
Average .	*827*	*6,190*

(*a*) Estimated.

The sands, now chiefly worked for ilmenite, contain about six per cent. of zircon, which, together with rutile, is separated by gravity concentrators and magnetic separators at the company's works at Manavalakurichi (8° 8′ ; 77° 18′). Zircon is used for the preparation of zirconium oxide, a highly refractory material suitable for crucibles and high temperature cements. The mineral is also used for the preparation of metallic zirconium.

IV.—MINERALS OF GROUP II.

Alum and Aluminous Sulphates.

[CYRIL S. FOX.]

Meaning of terms.

If the name *alum* is restricted to those double salts containing alumina, as the sesquioxide, with the sulphates of potassium, or sodium, or ammonium, and twenty-four molecules of water of crystallisation, then it can be definitely stated that no workable deposits of natural alum have so far been discovered in India. Of the other mineral substances, which can be grouped under the generic name of alum, there is no information to show that such material occurs in India in quantities which would justify exploitation. The potash alum, kalinite [Al_2O_3 (SO_3), K_2SO_4, $24H_2O$] has been found in small quantites in some places. The mineral alunite [$3Al_2O_3$ (SO_3), K_2SO_4, $6H_2O$] has been noted in association with sulphur in the Sanni mines of Baluchistan. The natural substances alunogen [Al_2O_3 (SO_3), $18H_2O$] and aluminite [Al_2O_3 (SO_3), $9H_2O$], are not alums, but are largely used in some countries for the preparation of alum; however, so far as is known these minerals are not available from extensive deposits for domestic purposes in India.

Manufacture.

Practically all the alum which was produced in India was made by the separation of sulphate of alumina from decomposed pyritous shales, with the addition of nitre or wood-ashes, to provide the hydrated double sulphates of alumina and potash, or of alumina and soda. At one time this was a relatively important local industry in certain parts of India, but the importation of cheap alum and the easy distribution of this article from the railways has resulted in the practical extinction of the native industry in most localities. Among the more important places where alum used to be manufactured may be mentioned :- Phulwaria in the Shahabad distinct of Bihar; Mhurr in Kachh (Cutch) and Maki Nai in Sind in the Bombay Presidency; Khetri and Singhana in Jaipur State in Rajputana; and Kalabagh and Kotki in the Mianwali district of the Punjab. In the Salt Range near Kalabagh, alum shales are found at two distinct horizons in the Eocene (Nummulitic) series, and again in the middle part

of the Jurassic series. Only one of these beds, situated at or near the base of the Eocene, is sufficiently rich in sulphur content to be used for alum making. The thickness varies from 7 to 10 feet at Kalabagh, to 25 to 40 feet at the Chichali pass near Kotki, a distance of 9 miles. About a mile beyond the latter locality the bed appears to die out. The pyrites is disseminated through the shales in microscopic particles, and the proportion of sulphur varies greatly, from 2 to nearly 13 per cent. Workable shale, known as *rol*, contains an average of 9·5 per cent. of sulphur, and is distributed in patches through the bed. Mining is conducted on no systematic plan, but the mineral is extracted by means of narrow, tortuous passages, rendered unbearably hot by reason of the decomposition of the pyrites, and without any provision either for ventilation or drainage.

A detailed account of the methods that were in use at Kalabagh was given by the late Mr. N. D. Daru [*Rec. Geol. Surv. Ind.*, XXXVIII, p. 32, (1909); also XL, pp. 265-282, (1910)]. It is interesting to compare the above description with that given for European practice, in Thorpe's Dictionary of Applied Chemistry, Vol. I, p. 176, (1921). Daru pointed out that the use of lime in the lixiviating tanks results in a very considerable loss of alum, and that this would be avoided by lining them with gypsum, which is found in abundance at Kalabagh itself. The product of the above manipulations is mainly soda-alum which is used at Delhi, Hissar, Sirsa, and other centres of the tanning and dyeing industries.

Pyritous shale suitable for the manufacture of alum has been noted in association with the coal seams of Makum, Lakhimpur

TABLE 117.—*Imports of Aluminous Sulphates and Alum during the years 1929 to 1933.*

Year.	Alum.		Aluminous Sulphate.	
	Quantity.	*Value.*	Quantity.	*Value.*
	Cwts.	*Rs.*	Cwts.	*Rs.*
1929	49,557	*3,38,312*	72,343	*2,91,136*
1930	27,145	*1,95,360*	66,223	*2,49,638*
1931	27,553	*1,88,619*	50,392	*1,74,866*
1932	21,710	*1,21,023*	36,066	*1,37,557*
1933	17,004	*88,778*	23,794	*80,360*
Average	*28,594*	*1,86,418*	49,763	*1,86,711*

district, Assam; Dandot colliery, Jhelum district, Punjab; and elsewhere in India. In view of the extended use, in place of alum, of aluminium sulphate which is manufactured from bauxite, these pyritous shales have not been worked since 1928. For figures of output from the Mianwali district, Punjab, 1919 to 1928, *see* the previous Review.

The above Table 117 shows that aluminous sulphates are on the average cheaper than alum. This point is of some importance in view of the fact that in most of its applications alum can be and is being replaced by aluminium sulphate. In this connection it is interesting to note that fairly large quantities of sulphate of alumina are annually prepared in India by treating bauxite with sulphuric acid. Messrs. D. Waldie & Co. of Calcutta state that they have used about 800 tons of raw bauxite periodically in the production of 600 tons of alum cake; 1,000 tons of sulphate of alumina (15 per cent.); and 800 tons of alum, crystal, at their Konnagar and Cawnpore factories.

The substitution of bauxite for China clay in the manufacture of aluminium sulphate is fully discussed in Thorpe's Dictionary of Applied Chemistry, Vol. I, pp. 171-173, (1921). It is there stated that the product of the China clay, 'alum cake', which is said to average 12 to 13 per cent. soluble alumina and 0·12 to 0·22 per cent. ferric oxide, contains the whole of the silica, iron, and other impurities present in the clay and that 60 per cent. of the alumina present in the clay is converted into sulphate. Bauxite has the advantage over China clay in that it is more readily soluble in sulphuric acid, needs no preliminary calcination and contains a larger percentage of alumina. It is subject to one drawback in that the average percentage of ferric oxide in the least ferruginous bauxites is comparatively large, as is seen in the accompanying analyses :—

	China Clay.		Bauxite.		
	1. Belgaum, India.	2. St. Austell, Cornwall.	3. Co. Antrim, Ireland.	4. Dept. de Var France.	5. Chota Nagpur, India.
SiO_2 . . .	44·00	46·20	13·0	15·80	1·32
TiO_2 . . .	..	..	6·0	1·20	6·50
Al_2O_3 . . .	41·30	41·10	42·00	66·50	60·49
Fe_2O_3 . . .	0·50	0·20	2·00	2·10	2·01
H_2O (combined)	11·90	12·50	21·00	15·20	28·79

The commercial products known as 'alumino-ferric' and 'alferite', which are prepared by digesting crude bauxite with sulphuric acid, are used in the preparation of all but the finest papers, in the precipitation of sewage and refuse liquids, and in the clarification and decolorisation of water supplies. The pure aluminium sulphate is only made from pure alumina, and this substance is obtained directly from bauxite by the Bayer process.

Amber.

[A. M. HERON.]

Production.

The production of Burmese amber during the five years 1929 to 1933 is shown in Table 118. The average annual production was 6·8 cwts. valued at Rs. 301 per cwt., compared with 19·0 cwts. valued at Rs. 348 per cwt. during the five years 1921 to 1928. The right to collect a 5 per cent. *ad valorem* royalty on amber in the Myitkyina and Upper Chindwin districts is farmed out with the jadeite royalties (*see* page 166).

TABLE 118.—*Production of Amber in the Myitkyina district, Upper Burma.*

—	Quantity.	*Value.*	
	Cwts.	Rs.	£
1929	19·6	*6,080*	454(*a*)
1930	2·1	*730*	54(*b*)
1931	..	..	..
1932	11·5	*1,940*	146(*c*)
1933	0·7	*1,500*	113(*c*)
Average .	*6·8*	*2,050*	*153*

(*a*) £1=Rs. 13·4. (*b*) £1=Rs. 13·5. (*c*) £1=Rs. 13·3.

Occurrence.

The Burmese diggings for amber are situated in the Hukong valley in the Nangotaimaw hills between Mainghkwan and Lalaung villages in about latitude 26° 20′ and longitude 96° 30′. The substance is found in pits from 20 to 40 feet deep, in blue clay probably of Miocene age; these

pits are dug in a haphazard way and are occasionally joined up by underground connections. Fragments of amber have been similarly found in association with beds of this age in other parts of Burma, for example at Mantha in the Shwebo district, and are said to have been met with on the oilfield of Yenangyat in the Pakokku district. Where definitely known it is usually associated with lignite or coal. Most of the material is brought from the Hukong valley in Upper Burma to Mandalay, where beads for rosaries, *nadaungs* (ear-cylinders), and other trinkets for personal ornament are made from the transparent varieties.

Chemical and physical properties.

The amber of Burma differs in chemical and physical characters from previously known varieties and consequently the name *burmite* has been suggested for it as a specific distinction.[1] The well-known amber of eastern Prussia contains from 2½ to 6 per cent. of succinic acid and is known to the mineralogist as *succinite*. The Burmese amber is harder and denser, and it is doubtful whether it contains any succinic acid, though the products of its dry distillation include formic acid and pyrogallol; its ultimate chemical composition has been determined to be as follows :-

	Per cent.
Carbon	80·05
Hydrogen	11·50
Oxygen	8·43
Sulphur	0·02
	100·00

The specific gravity of burmite varies between 1·030 and 1·095. It is distinguished from many other amber-like resins by its superior hardness and greater toughness, which render it fit for carving and turning. It varies in colour from pale yellow to dull brown, and possesses a peculiar fluorescence, like that which distinguishes the Sicilian variety, *simetite*.

Apart from the occurrence of a large percentage of discoloured opaque pieces, many of the large fragments obtained are damaged by cracks filled with calcite; otherwise there appears to be a large quantity of material which might be put on the market with profit.

[1] O. Helm, *Rec. Geol. Surv. Ind.*, XXV, p. 180, (1892), and XXVI, p. 61, (1893).

Arsenic.

[A. M. HERON.]

The chief indigenous source of arsenic is the orpiment mines of Chitral, where the mineral is exploited by the Mehtar of that country. Mr. G. H. Tipper, who carried out a survey of the State, reports that the orpiment is in most cases accompanied by realgar and fluorspar, and the mines, judging from the size and extent of the workings, are of considerable age. The six principal areas with their heights above sea-level are:—(*i*) Mirgasht Gol (11,000 feet); (*ii*) Aligot (13,000 feet); (*iii*) Londku (11,000 feet); (*iv*) Wizmich (16,000 feet); (*v*) Moghono Zom (15,000 feet); Stack (14,000 feet). The last four deposits are on the same line of strike. The arsenic ore occurs close to a band of basic intrusive rock in calcareous shales associated with marble. The output of the mines fell off during the earlier years of the century and was less than 10 tons in 1905-06. No returns are available for recent years, although the industry is still carried on. The difficulties in working the present mines include the inaccessibility of the area, the inclemency of the weather, the unscientific lay-out of the mines and the lack of adequate ventilation. Mr. Tipper considers that there are good prospects of discovering fresh untouched deposits in Chitral.

Chitral.

A seam of arsenopyrite, one foot thick, of which about two-thirds consist of ore, is recorded from the northern flank of Samthar Hill near Darjeeling. A small outcrop of the same mineral is known to occur near Barali in the Bhutna valley, Kashmir. The occurrence of orpiment near Munsiari in Kumaon has long been known,[1] small quantities of this mineral and of realgar, the other sulphide, being sold in the bazars of northern India; but it was not till 1906, when Drs. G. de P. Cotter and J. Coggin Brown found scattered fragments of both minerals lying on the moraine material of the Shankalpa glacier, that any precise locality was ascertained. The ore was not found *in situ*, but had probably come from the hill-face immediately above.[2] Large lumps of leucopyrite, and arsenide of iron, have been found in the pegmatites of the mica-mining field near Gawan in the Hazaribagh district,[3] and other arsenides have been found

Himalayas and Bihar.

[1] A. W. Lawder, *Rec. Geol. Surv. Ind.*, II, p. 88, (1869).
[2] *Op. cit.*, XXXVI, p. 129, (1908).
[3] T. H. Holland, *Mem. Geol. Surv. Ind.*, XXXIV, p. 51, (1902).

associated with pyritous lodes in various places, but no attempt has been made to recover arsenic from these occurrences.

Exports and imports.

Details with regard to the production and use of Indian arsenic are not available, but there has been a considerable trade in both the Indian and foreign commodity, presumably in the form of white arsenic. Owing to the discontinuance of the old system of registration of trade by land and the introduction of a new system of registration, from the 1st April, 1925, of selected commodities only and at certain selected railway stations adjacent to important land frontier routes, figures for the imports of arsenic—including orpiment—are no longer available.

Chinese orpiment.

Orpiment, the yellow sulphide of arsenic, is largely imported into Burma from western China for use mainly as a pigment. The mineral is used as a pigment in the manufacture of Indian ornamental lac-wares and the Burmese lacquer-work; in the latter the favourite greens of the Pagan workers are produced by mixtures of indigo and orpiment, and the so-called gold-lacquer of Prome by powdered orpiment and gum. Orpiment is used also for the designs on the Afridi wax-cloths.

Asbestos.

[A. L. Coulson.]

The history of the production of asbestos in India does not lead one to anticipate a bright future for the mineral, though, as will be seen, there seems ample scope for an indigenous asbestos products manufacturing industry. The total amount of asbestos so far extracted in India is only 4,438 tons valued at Rs. 2,38,568, the peak production in any one year being 1,818 tons in 1920.[1] The first production was in 1906, when 21 tons were extracted from veins in actinolite-schist in the Hassan district of Mysore, which has produced altogether 3,468 tons valued at Rs. 1,33,114, the largest amount from any single district in India and gained chiefly during the years 1917 to 1923. Next in importance comes Seraikela State in Bihar and Orissa, which at intervals from 1921 to 1932 produced 502 tons of brittle amphibole asbestos valued at Rs. 62,910.

[1] A. L. Coulson, *Mem. Geol. Surv. Ind.*, LXIV, Pt. 2, pp. 248-249, (1934).

Perhaps the most important deposits in India from the point of view of quality are those in the Pulivendla taluk of the Cuddapah district of Madras, from which 200 tons of excellent chrysotile asbestos, valued at Rs. 27,954, were extracted in the years 1924 to 1930. The asbestos occurs at the junction of a bed of Vaimpalli limestone with an intrusive dolerite sill beneath it and the asbestos horizon has been traced from Brahmanapalle (14° 26′ : 78° 12′) to Lopatanutula, a distance of some 9½ miles N. N. W.[1] The mines of the Mysore Asbestos Mines, Ltd., at Brahmanapalle were dismantled in 1930, as the company was unable to market the product economically in view of the current world prices and supplies of asbestos.

Asbestos has also been produced from the Bangalore district of Mysore (174 tons in 1920 and 1921), Tumkhera Khurd in the Bhandara district of the Central Provinces (total of 84 tons at intervals from 1908 to 1924) and Ajmer-Merwara in Rajputana (12 tons in 1927 and 1931). An important deposit of amphibole asbestos, so far undeveloped, occurs at Dev Mori in Idar State, Bombay.[2] Details of these and other occurrences in India apart from those in the Ceded Districts of Madras will be found on pages 198 to 218 of *Memoirs*, Volume LXIV, Part 2, (1934).

The quantity and value of asbestos produced in India during the years 1929 to 1933 are given in Table 119 below, there being no recorded production in 1933 :—

TABLE 119.—*Production of Asbestos in India during the years 1929 to 1933.*

	1929		1930		1931		1932		1933	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Bihar and Orissa. Seraikela State	80·0	*10,000*	..	..	..	..	90·0	*9,000*	..	..
Madras. Cuddapah district	88·4	*3,160*	33·2	*1,190*	..	..		..	..	..
Mysore. Hassan district	150·0	*3,000*	..	..	..	..	..	..	..	..
Rajputana Ajmer-Merwara	..	..	..	..	6·0	*70*	..	..	..	..
TOTAL	**318·4**	*16,160*	**33·2**	*1,190*	**6·0**	*70*	**90·0**	*9,000*	*nil*	*nil*

[1] *Ibid.*, pp. 155-173.
[2] C. S. Middlemiss, *Mem. Geol. Surv. Ind.*, XLIV, Pt. 1, p. 100, (1921).

In 1933, after a lapse in such imports for some seven years, 19 cwts. of raw asbestos were imported into India, an amount not large enough to warrant the reopening of the dismantled mines. During the years 1929 to 1933, however, the average annual amount of manufactured asbestos (packing, sheets and plates of asbestos cement, etc.) imported into India was valued at Rs. 21,80,380. There seems no reason why India should not attempt to capture this large trade by the creation of an indigenous asbestos products manufacturing industry.

Barytes.

[A. L. COULSON.]

On account of its high specific gravity, ground barytes (barite or heavy spar), the sulphate of barium, is used in India and Burma for weighting the mud-fluid in rotary drilling, a use which has increased greatly during the past quinquennium; it is also used as an inert filler in paper, cloth, linoleum, etc., and as a white pigment and an inert extender in paint manufacture, the last use formerly consuming the largest amounts of barytes used in India.

The greater part of the world's output of barytes, however, is consumed in the manufacture of lithopone, which is known by numerous other trade names but consists approximately of 70 per cent. barium sulphate and impurities such as lime, ferric oxide and barium carbonate, and 30 per cent. of zinc sulphide and zinc oxide. The amount of zinc oxide, however, is small, varying from about 1 to 3 per cent. To manufacture a ton of commercial lithopone, 98 to 99 per cent. of which will pass through a 300-mesh screen, over 1¼ tons of barytes are required or a total of about four tons of all raw materials, including zinc, barytes, sulphuric acid and coal. Lithopone is used extensively in the manufacture of paints and of high-grade rubber goods such as motor tyres, etc.

Other uses for barytes are as a furnace-lining and in the manufacture of barium chemicals.[1]

Details of the production and consumption (production + imports) of barytes in India are given in Tables 120 and 121.

[1] *See* A. L. Coulson, *Mem. Geol. Surv. Ind.*, LXIV, Pt. 1, pp. 118-127, (1934), for an account of the marketing and uses of barytes.

TABLE 120.—*Production of Barytes in India during the years 1929 to 1933.*

	1929		1930		1931		1932		1933	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Madras.										
Anantapur ..	..	..	..	..	..	..	166	*1,726*	216	*2,045*
Cuddapah ..	..	..	..	..	1,335	*8,750*	1,359	*18,535*	3,974	*29,810*
Kurnool ..	802	*5,151*	5,633	*42,578*	4,158	*33,490*	949	*6,213*	1,354	*8,592*
Rajputana.										
Alwar State	2,948	*17,588*	1,164	*6,984*	161	*966*	483	*2,898*	107	*1,070*
TOTAL	3,750	*22,739*	6,797	*49,562*	5,654	*43,206*	2,957	*29,372*	5,651	*41,517*

TABLE 121.—*Consumption of Barytes in India during the years 1929 to 1933.*

Year.	PRODUCTION.		IMPORTS.		CONSUMPTION.		
	Quantity.	*Value*[1] (pit's mouth).	Quantity.	*Value.*	Quantity.	*Value.*	Share of production (by weight).
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Per cent.
1929	3,750	*22,739*	2,826	*1,74,261*	6,576	*1,97,000*	57·0
1930	6,797	*49,562*	5,785	*2,98,200*	12,582	*3,47,762*	54·0
1931	5,654	*43,206*	4,530	*2,60,695*	10,184	*3,03,901*	55·5
1932	2,957	*29,372*	2,173	*99,615*	5,130	*1,28,987*	57·6
1933	5,651	*41,517*	2,914	*1,43,462*	8,565	*1,84,979*	66·0

Since 1918, when the production of barytes in India commenced, the imports of that mineral have never exceeded the total production. Germany, the world's largest producer, is the chief source of barytes imported into India.

Prior to 1924, the Kurnool district of Madras supplied most of the Indian production of barytes. During the years 1924 to 1929, Alwar State held pride of place; but from 1930 to 1933, the market was recaptured by the Madras product, partly due to an increasing output from the Cuddapah district from 1931 onwards. The maximum production in India of 6,797 tons in 1930 was due largely to barytes extracted during prospecting operations in the

[1] Sale prices must, of course, be much higher than the pit's mouth values but no accurate figures are available.

Kurnool district, 4,235 tons out of the total Madras production of 5,033 tons being so obtained from 'Non-Act' mines.

A summary has recently been given of all known occurrences of barytes in India.[1] Accordingly it is necessary to make reference here only to the most important.

Madras. The barytes occurs in replacement and fissure veins in limestones, dolerites and basalts, the limestones belonging to the Vaimpalli stage of the Papaghni series of the Cuddapah system and the associated igneous sills being intruded in late or possibly post-Cheyair or Nallamalai times.

Anantapur district. Chief deposits are at Nerijamupalle (14° 32′ : 78° 1′) and Mutssukota (14° 51′ : 77° 52′) in the Tadpatri *taluk.* The former is believed to be responsible for the recorded production from the district and it is estimated that 75,000 tons of barytes occur at the latter locality. Both deposits are in Vaimpalli limestones.

Cuddapah district. Perhaps the most important single deposit of barytes in India occurs as a vein in basalt at Kottapalle (14° 22′ : 78° 21′) in the Pulivendla *taluk*, the available quantity being probably very large[2]. Numerous other veins occur near this village, mostly in trap but sometimes in limestone.

Kurnool district. The chief deposits are at Balapalapalle (15° 27′ : 78° 6′), west of Betamcherla, and at Hussainpuram (15° 14′ : 77° 49′), Ramapuram (15° 17′ : 77° 52′), Valasala (15° 23′ : 77° 58′), Rahimanpuram (15° 24′ : 78° 3′) and Gattimanikonda (15° 32′ : 78° 11′) all these localities being in the Dhone *taluk* and all the deposits in Vaimpalli limestones. Another important deposit is at Janapalacheruvu (15° 28′ : 79° 9′) in the Cumbum *taluk*, the country-rock not being definitely known.

Rajputana. Alwar State. The barytes occurs in veins in the Alwar quartzites of the Delhi system, filling fissures in the less compact and more easily weathered varieties; it is not an original constituent of the quartzites. The chief deposits are at Sainpuri (27° 43′ : 76° 38′), Bhakhera (27° 32′ : 76° 36′) near Alwar, and Rampur (27° 9′ : 76° 37′).[3]

Bihar and Orissa. The nearest deposits to Calcutta are those at Chas Road (23° 25′ : 86° 12′) in the Manbhum

[1] *Ibid.*, pp. 91-102.

[2] *Ibid.*, p. 19.

[3] S. K. Roy, *Rec. Geol. Surv. Ind.*, LIV, pp. 238-239, (1923).

district[1] and at Khatangtola[2] (22° 22′ : 85° 4′) in Gangpur State and Kolpotka (22° 22′ : 85° 6′) in the Singhbhum district[3]; Calcutta, however, continues to obtain its supplies from the larger deposits of Madras and Alwar.

Bauxite.

[CYRIL S. FOX.]

The occurrence of highly aluminous laterites in India was first noted about 50 years ago by F. R. Mallet[4], but the term 'bauxite' was applied to this Indian material 20 years later by Sir Thomas Holland[5] who showed that workable quantities existed in this country of a quality suitable for the extraction of aluminium. Dr. L. L. Fermor[6] has since defined what 'laterite' is and Dr. C. S. Fox has discussed the differences between French bauxite and Indian laterite in his book published three years ago.[7] As a result of Sir Thomas Holland's writings, efforts to work Indian *bauxite* were made and since 1910 there has been a small but variable production of this substance from some of the more favourably located Indian occurrences.

Production. The output during the period 1929-33 is shewn in the accompanying table.

TABLE 122.—*Production of Bauxite during the years 1929 to 1933.*

Year.	Quantity.	*Value.*	
	Tons.	*Rs.*	£
1929	9,044	*72,352*	5,399(*a*)
1930	2,514	*20,112*	1,490(*b*)
1931	4,298	*8,954*	663(*b*)
1932	4,467	*8,728*	656(*c*)
1933	1,000	*3,000*	226(*c*)
Average	4,265	*22,629*	1,687

(*a*) £1=Rs. 13·4. (*b*) £1=Rs. 13·5. (*c*) £1=Rs. 13·3.

[1] A. L. Coulson, *op. cit.*, LXVIII, p. 242, (1934).
[2] A. L. Coulson, *Mem. Geol. Surv. Ind.*, LXIV, pp. 92-94.
[3] Director's General Report, *Rec. Geol. Surv. Ind.*, LXII, p. 31, (1932).
[4] *Rec. Geol. Surv. Ind.*, XVI, Pt. 2, p. 113, (1883).
[5] *Rec. Geol. Surv. Ind.*, XXXII, Pt. 2, p. 175, (1905); *Trans. Min. Geol. Inst. Ind.* II, p. 32, (1908).
[6] *Geol. Mag.*, Decade V, Vol. VIII, pp. 454-462, 507-516, 559-566, (1911).
[7] 'Bauxite and Aluminous Laterite', London, 2nd edn., (1932).

At the present time, the world's production of bauxite, roughly 1,500,000 tons, is used in the following approximate proportions in several industries :—

	Per cent.
For aluminium after conversion to alumina	70
For the manufacture of chemicals	15
In the production of abrasives	8
For the preparation of refractories, for bauxite cement, for the purification of kerosene, and for other purposes excluding building stone	7

The world's production of bauxite increased from about one million tons in 1924 to almost double that figure in 1928. The two million ton figure was touched in 1929, but then followed an almost steady fall until, in 1933, the production was less than a million tons. The worst year in this quinquennial period was 1932, so that there is promise of improved trade for the immediate future. Among the great producers—France, the United States of America, Hungary and British and Dutch Guiana—the first and the last have suffered least (a fall of 25 per cent.) during this depression, but Hungary and British Guiana (falls of 75 per cent. in output) have faced a difficult time. The Indian production for 1933 is lower than it has been since 1919.

Classification.

The two main classes of ore are (1) the Mediterranean (*terra rossa*) type and (2) the Indian (lateritic) type. Under the former class are included the bauxites of Spain, France, Italy, Yugo-Slavia and Rumania—types which seldom contain more than 14 per cent. of combined water and indicate a certain degree of dehydration. The latter class includes most of the bauxites of America, Africa, India and Australia; these deposits appear to be of a geologically younger type and contain from 22 to 30 per cent. of combined water with a somewhat lower alumina content (54 per cent.) than the Mediterranean type.

For commercial purposes it is convenient to classify bauxites into the following varieties :—

(*a*) *Normal bauxite.* Fair quality with 55 to 60 per cent. alumina, and high-grade ore with over 60 per cent. alumina. Total impurities not to exceed 20 per cent. excluding the combined water content The chief impurities, ferric oxide, silica and titania, each not to exceed 5 per cent.

(*b*) *White or siliceous bauxite.* To have upwards of 55 per cent. alumina and not more than 20 per cent. impurities excluding the combined water. Silica from over 5 to about 20 per cent. Ferric oxide less than 5 per cent. Titania up to 5 per cent. This class of ore is most frequently used for chemical purposes or the preparation of alum and other aluminium salts.

(*c*) *Titaniferous bauxite.* The alumina to average 55 per cent. and the total impurities excluding combined water not to exceed 25 per cent. Titania above 7 per cent. Silica less than 5 per cent. Ferric oxide not to exceed 10 per cent. These bauxites are rare except in India but have a great future before them owing to the valuable nature of the titaniferous slime which can be obtained as a by-product when the ore is purified by the Bayer process.

(*d*) *Red* or *ferruginous bauxite.* Alumina content to be upward of 52 per cent. Total impurities not to exceed 25 per cent. Ferric oxide between 10 and 25 per cent. Silica to be less than 5 per cent. Titania normally less than 5 per cent. This variety of bauxite is most commonly used by aluminium reduction companies.[1]

Analyses of various types of bauxite from India and abroad are given in Table 123.

Prospects.

The Indian bauxite industry has never been actively developed in spite of several efforts, justified by the large occurrences of this material in various parts of the Peninsula. The trade, so far, has depended on small orders from oil companies for the purification of kerosene, and smaller demands by chemical companies for the preparation of aluminous sulphates, etc. During the past few years, small quantities of bauxite refractories (for furnaces) have been made in an almost experimental manner by Messrs. Burn & Co., at Raniganj, and the question of preparing abrasive products, *e.g.*, grinding-wheels, etc., has been considered. This research must be regarded only as a trial with fused bauxite and is not yet concluded. An investigation has also been conducted[2] into the preparation of calcium aluminate cement, which was successful on the small quantities

[1] *Min. Journ.*, Vol. CXXXIX, No. 4558, p. 986, (30th December, 1922).
[2] By C. S. Fox.

TABLE 123.—*Analyses of characteristic Bauxites.*

—	France.				Roumania.		Dalmatia.	Italy.		United States.				British Guiana.		India.			Gold Coast.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. SiO_2	0·80	0·80	0·29	13·30	1·49	0·80	0·89	2·79	7·91	2·90	7·91	10·13	0·62	2·73	1·00	1·18	1·44	0·30	1·72	0·62
2. TiO_2	2·80	3·50	0·80	2·40	3·12	2·80	—	1·27	—	3·40	3·50	—	1·05	0·10	1·10	8·80	6·32	7·40	1·89	1·66
3. Al_2O_3	58·60	76·40	60·60	63·7	59·66	65·50	51·85	57·60	58·86	58·21	62·05	55·59	64·91	64·38	70·90	60·23	62·32	66·98	64·40	59·05
4. Fe_2O_3	26·20	4·80	26·0	5·5	23·66	21·30	26·82	26·55	18·62	3·60	1·66	6·08	0·28	0·50	0·80	2·64	2·65	5·92	2·27	12·19
5. CaO	—	—	—	—	—	—	—	—	0·30	—	—	—	—	—	—	0·82	trace	—	—	—
6. MgO	—	—	—	—	—	—	—	—	0·37	—	—	—	—	—	—	0·30	0·38	trace	—	—
7. H_2O (comb.)	10·90	14·30	10·40	14·30	11·81	9·96	19·97	11·71	13·27	31·89	30·31	28·99	33·00	32·29	26·30	25·40	26·27	21·40	29·24	26·47

1 and 2. Loupain (Herault), analyses by M. Blot for M. Arsandaux. 3 and 4. La Calre (Var), analyses ditto. 5. Cucul (Bihar Mts.), analysis by M. Blot for R. Lachmann. 6. Dealul Cruci (Bihar Mts.), analysis ditto. 7. Dernis (Dalmatia), analysis by Kucan for Kispatic. 8. Lecce dei Marsi (Abruzzo), analysis given by G. Aichino. 9. Pietraroja, Benevento (Campagna), analysis given by Mattiralo. 10. Cherokee Co. (Alabama), analysis given by H. McCalley. 11 and 12. Arkansas, analysis given by J. C. Branner. 13. Floyd Co. (Georgia), analysis given by T. L. Watson. 14. Yarikita River (British Guiana). analysis given by J. B. Harrison. 15. Essequibo River, analysis ditto. 16. Bargawan hill (Katni), Jabalpur District, analysis by R. V. Briggs. 17. Panhala Fort. Kolhapur State, analysis by R. V. Briggs. 18. Rajadera, Ranchi District, analysis Geological Survey of India Laboratory. 19 and 20. Mt. Ejuanema bauxite (after A. E. Kitson).

made. The results have been sufficiently satisfactory for experimental work on a small working scale and an experimental plant is contemplated.

The efforts to utilise Indian bauxite, including normal low-silica laterite, in the preparation of refractories, abrasives and cement are the outcome of a slowly growing increase in demand for such products in India. The early hopes of exporting raw or partially calcined bauxite have usually been disappointed by the high cost of transport to those consumers who have been attracted by certain special qualities of the Indian material. In a few cases, business has been terminated owing to lack of sufficient care by vendors in quarrying the material without the precaution of sampling and making analyses. The aspect of the trade has, however, now been fairly recognised and the conditions and requirements of possible consumers have been carefully studied by many vendors.

With regard to the chief use of bauxite as the ore of aluminium it had been thought that, until supplies of cryolite were readily available in India, the question of establishing aluminium reduction works in India, except by one or other of the great producers of aluminium, was not one for serious consideration. As has recently been pointed out[1], cryolite is now available and the future outlook for aluminium is not now governed by control of essential raw materials but simply by competition between a new producer and an established producer under, at present, depressed trade conditions. However, a company has been formed to develop the exploitation of the bauxite of Kolhapur State and to erect aluminium reduction works in their vicinity. If this courageous venture succeeds, it will constitute the inauguration of an Indian aluminium industry.

No virgin aluminium is prepared in India, but aluminium ware is manufactured from imported metal at several places in this country.

Aluminium.

The British Aluminium Co., Ltd., is represented in Calcutta by the Aluminium Manufacturing Co., Ltd. Table 124 shows the imports of aluminium into India during the decade 1924 to 1933. It is seen that the greatest amount was about 8,500 tons in 1929 but that a minimum was reached in 1932 when only 1,150 tons were imported. From the depth of this depression, it seems probable that some other metal has entered successfully into competition with aluminium, possibly copper and brass, at prevailing low prices.

[1] *Min. Journ.*, Vol. CLXXXVI, No. 5164, p. 610, (11th August, 1934).

Table 124.—*Imports of Aluminium into India during the years 1924 to 1933 (in cwts.).*

	1924	1925	1926	1927	1928	Average	1929	1930	1931	1932	1933	Average
Aluminium—												
Unwrought (ingots, blocks, bars) .	3,690	4,164	4,591	4,467	1,858	*3,754*	1,026	978	44	238	138	*485*
Wrought—												
Circles	77,318	74,372	74,080	103,862	110,905	*88,107*	157,006	142,560	42,251	16,292	26,114	*76,844*
Sheets	2,888	3,358	4,093	6,427	5,120	*4,377*	4,125	2,608	1,640	1,130	1,740	*2,249*
Other manufactures . . .	7,645	7,677	7,329	6,404	9,285	*7,668*	8,627	6,957	5,426	5,394	6,262	*6,533*
TOTAL .	91,541	89,571	90,093	121,160	127,168	*103,906*	170,784	153,163	49,361	23,051	34,254	*86,111*

R. J. Anderson in his great work 'The Metallurgy of Aluminium and Aluminium Alloys (1925)', has given an exhaustive account of the aluminium reduction methods and applications of to-day. For an account of the Indian bauxite occurrences see *Memoirs, Geological Survey of India*, Vol. XLIX, (1923). A general review of the bauxite occurrences of the world and an outline of the aluminium industry has been given by Dr. C. S. Fox in his book 'Bauxite and Aluminous Laterite' published in 1932. Finally, N. V. S. Knibbs in his valuable brochure 'The Industrial Uses of Bauxite (1928)', has discussed the utilisation of bauxite for aluminium reduction, oil refining, abrasives and refractory purposes and in the manufacture of aluminous cements. In the previous quinquennial review, for the period 1924-28[1], these aspects of the utilisation of bauxite were outlined, but it has not been considered necessary to repeat that information here.

Literature.

Bismuth.

[A. M. HERON.]

The only part of the Indian Empire where bismuth ores have been extracted—and then only on a very small commercial scale—is the Tenasserim division of Lower Burma. Native bismuth and the sulphide, bismuthinite, occur in the wolfram and cassiterite-bearing veins of certain localities in the Tavoy district, and also in the adjoining districts of Mergui and Amherst.

Dr. Coggin Brown states[2]—

'the quantity of the bismuth minerals found in the veins is in itself too insignificant to permit of their profitable extraction on this account alone, and the insignificant amount of bismuth which has been exported from Burma up to the present time has been recovered as a by-product in the sluicing of eluvial deposits for wolfram and tin-stone. As the veins are broken down under the general action of denudation they shed their metallic contents into the surface soil. Deposits formed in this manner on the hill sides are often profitable to work on account of their metallic contents. The bismuth minerals are either hand-picked out of the clean concentrates after sluicing operations, or recovered chemically from the tin-ore after magnetic separation. The chemical process is not carried out in India, but is known to have been performed on certain Tavoyan tin-ores after their arrival in the United Kingdom. For this reason, the total amount of the small quantity of bismuth ore produced in recent years in Burma is not known, and the only recorded figures are 5 cwts. of ore valued at £163, shipped separately as such. The future output of bismuth ores from India depends entirely on their separation as by-products in the wolfram and tin-ore mining industry of Lower

[1] *Rec. Geol. Surv. Ind.*, LXIV, pp. 335—341, (1930).
[2] *Bull. Ind. Industries and Labour*, No. 6, pp. 23, 24, 28.

Burma. No deposits have as yet been discovered rich enough to exploit for their bismuth contents alone; on the other hand it is certain that small amounts of bismuth minerals are wasted because of the prevalent ignorance of their properties and value. But even when this is allowed for, it must be admitted that the quantities probably obtainable from known deposits in the Tavoy and Mergui districts are comparatively insignificant.'

TABLE 125.—*Production of Bismuth in the Tavoy district, Burma, in 1929 to 1933.*

Year.	Quantity and value.
1929	88 lbs. valued at Rs. 308 (£23)
1930	112 " " " 323 (£24)
1931	42 " " " 84 (£6)
1932	27 " " " 54 (£4)
1933	80 " " " 160 (£12)

Borax.

[E. R. GEE.]

No undoubted occurrence of borax is known within British Indian territory, and the material exported, which during the last five years has averaged annually 1,112 cwts., of a value of Rs. 20,649 (*see* Table 126), is practically all obtained from Tibet and Ladakh, being imported across the frontier into the Punjab and the United Provinces. The quantity from Ladakh is very small, the reported total for the year 1929 being 7·3 cwts.; there are no production figures for subsequent years. The word *tincal*, by which it is known in the bazars, is in common use on the Punjab frontier in the Himalayan passes, where can be seen herds of goats and sheep coming down in the spring from Tibet, each carrying two small bags of borax or salt to be bartered for Indian and foreign stores.

TABLE 126.—*Exports of Borax by sea from India during the years 1929-30 to 1933-34.*

Year.	Quantity.		*Value.*	Value per cwt.
	Cwts.	Metric tons.	*Rs.*	Rs.
1929-30	1,816	92	*34,843*	19·18
1930-31	850	43	*16,356*	19·24
1931-32	1,230	62	*22,433*	18·24
1932-33	749	38	*15,229*	20·33
1933-34	915	47	*14,383*	15·72
Average	1,112	56	*20,649*	18·57

In addition to the borax sent by sea to foreign countries, small quantities cross the frontier into Nepal, Kashmir, Kelat, Afghanistan, Tibet and China. Of late years, the export trade in borax has very seriously declined. Fifty years ago the quantity sent out of India amounted to over 16,000 cwts. a year, valued at £24,000. At that time the greater part of the material exported went to the United Kingdom (14,134 cwts. in 1883-84), but, with the discovery of large deposits of calcium borate in America, the demand for borax from India ceased, and, under normal conditions, the only large customers are now the Straits Settlements and China (Hongkong).

The annual amount of borax imported into India across the frontier averaged 22,969 cwts. of the value of Rs. 5,70,520 for the period 1919 to 1923. Owing to the discontinuation of the old system of registration of trade by land since 1st April, 1925, figures for the imports of borax by land are no longer available. The annual amount imported by sea during the past five years has averaged (as shown in Table 127) 20,370 cwts. of the value of Rs. 2,21,767 as compared with 13,947 cwts., of the value of Rs. 2,36,248 during the period 1924-25 to 1928-29.

TABLE 127.—*Imports of Borax by sea during the years 1929-30 to 1933-34.*

Year.	Quantity.	*Value.*	Value per cwt.
	Cwts.	*Rs.*	Rs.
1929-30	19,081	*2,13,708*	11·20
1930-31	13,150	*1,59,502*	12·13
1931-32	21,011	*2,39,673*	11·34
1932-33	32,830	*3,25,483*	9·91
1933-34	15,750	*1,70,470*	10·82
Average .	20,370	*2,21,767*	10·89

The borax obtained in the Puga valley of Ladakh, Kashmir, is deposited from hot springs associated with sulphur deposits, which probably represent the final phase of declining volcanic action. The material collected in Tibet is obtained from salt lakes, which have possibly obtained their borax in a similar way from hypogene sources. In other parts of the world, as in California, Argentina, Bolivia, and Chile, deposits of calcium borate, colemanite, are worked for their boracic acid, besides the borax of salt lakes and marsh deposits. In Italy, borax is obtained from volcanic fumaroles.

Building Materials.

[A. M. HERON.]

As remarked by Sir Thomas Holland,—

> 'if the extent of the use of building materials could be expressed by any recognised standard, it would form one of the best guides to the industrial development of a country. The attempt made to obtain returns of building stones, road metal, and clays used in India was abandoned when it was shown, in 1899, that the returns could not possibly rank in value much above mere guesses.'

In the absence of statistics, it is difficult to express shortly the trade in a material so widespread as common building stone. There are, however, a few features which are specially developed in, if not peculiar to, India. In the southern part of the Peninsula, various igneous rocks—the charnockite series near Madras, and the gneissose granites of North Arcot and Mysore—are largely used ; in the centre, slates and limestones from the Cuddapah series, and basalt from the Deccan trap-flows are quarried. In Central India, the Central Provinces and the United Provinces, the great Vindhyan system provides incomparable sandstones and limestones, while in Bengal and the Central Provinces the Gondwana sandstones are used on and near the coalfields. In the Narbada valley the so-called coralline limestone of the Bagh series forms an excellent building stone with a certain claim to inclusion in the ornamental class. Among the younger rocks the nummulitic limestones in the north-west and in Assam are largely quarried, while the foraminiferal Porbandar stone in Kathiawar[1] is extensively used in Bombay and Karachi.

[1] A 'Memoir on the Economic Geology of Navanagar State' by G. E. Howard Adye, (1914), deals with the economic uses of the miliolite limestones, Deccan trap rocks, both acid and basic, and the laterite of this State.

The abundant occurrence of concretionary carbonate of lime in the great alluvial plains, and the extensive development of laterite on the Peninsula and in Burma are dependent, in their more pronounced forms, on conditions peculiar to tropical climates, and these two substances, the so-called *kankar* and laterite, are about the most valuable assets in building material possessed by the country.

Imports.

The three great physical divisions of India, being the result of three distinct geological histories, show general contrasts in the materials available for simple as well as ornamental building purposes. In the great alluvial plains, buildings of importance are usually made of brick, but the surrounding tracts furnish a supply of stone, which is steadily increasing with improved facilities for transport. The monotonous line of brick and stucco buildings in Calcutta has been relieved by the introduction of Vindhyan sandstones from Mirzapur and the calcareous freestones and buff traps brought from the western coast. But the use of Italian marbles, mainly for floorings and, in a smaller way, the introduction of polished granite columns and blocks from Aberdeen and Peterhead, have continued, mainly because these materials, which are no better than, and possibly on the whole inferior to, those of Indian origin, are placed on the market at cheap rates and in a manner suitable to the immediate requirements of the builder and architect. The distance of much of the Indian marble, especially the higher grade material, from the sea-board, precludes cheap transport and prevents the Indian stone from competing in foreign markets with material from elsewhere. With regard to immediately local demand, however, this comparative inaccessibility protects indigenous supplies, and these are able to undersell foreign marble, the transportation of which includes a considerable land journey.

During the years 1928-29 to 1932-33 the value of building and engineering materials imported from foreign countries into India has had an average annual value of Rs. 1,05,73,631, exclusive of stone and marble, which have averaged Rs. 5,33,924 annually during the same period. The substances included in the trade statistics under the heading of building materials and entered into the above total comprise asphalt, bricks and tiles, cement, chalk and lime, clay and earthenware piping. The values of some of these are given in the section on clays. The quantity of cement imported

annually during these years has averaged 106,219 tons valued at Rs. 51,21,344 and the annual imports of chalk and lime during the same period have averaged 1,555 tons valued at Rs. 60,730.

As Sir Thomas Holland has remarked[1]—

Ornamental building stone.

'It is naturally surprising to find that a country, which owes its reputation for architectural monuments as much to the fact that it possesses an unlimited supply of ornamental building stones as to the genius of its people, is dependent on foreign supplies to the extent indicated by these import returns. It can hardly be an accident that each dynasty which has existed in India since the wonderful Buddhist topes of Sanchi and Bharhut were erected, has been marked by the erection of great monuments in stone, and there can be little doubt that the abundance of suitable material has been an important contributory cause in the growth of India's reputation for architecture.'

Besides the architectural remains left by the Buddhists, there are famous works in stone by the Hindus of the eighth to tenth centuries, including the great Dravidian temples of southern India, mostly built of granites and other crystalline rocks, and the richly ornamented buildings of Orissa and of Chanda built of Gondwana sandstones. The Pathans and Moghals utilised both the Vindhyan sandstones of Central India and the beds of marble in Rajputana for building their magnificent mosques, palaces and tombs in the cities of northern India. It is only necessary to mention here Akbar's city of Fatehpur Sikri, where the red and mottled sandstone of the Bhander series was used, and the famous Taj, built mainly of white Makrana marble, with elaborate inlaid work of yellow marble and shelly limestone from Jaisalmer, onyx marble from the Salt Range, black calcareous shales from the Vindhyans of Chitor, malachite from Jaipur, carnelians and blood-stones from the Deccan trap, and red jasper from the Gwalior (Bijawar) series.

The delicate and intricate carvings, for which some varieties of the Indian sandstones are so well suited, are admirably shown in an 'Illustrated Catalogue of Ornamental Carved Stone in Gwalior', published by the Department of Commerce and Industry, Gwalior, in 1912.

A table giving the specific gravity and porosity of 122 Indian building stones, compiled by Dr. G. de P. Cotter, is given in the *Records of the Geological Survey of India*, Vol. LXVI, Pt. 3, pp. 348—355, (1932).

[1]*Rec. Geol. Surv. Ind.*, XXXII, p. 103, (1905).

Although, in most cases, reliable statistics concerning the production of building stones in India are not obtainable, yet we give here such figures as are available, excluding those relating to marble and slate, which are treated in separate sections.

Granite and gneiss.

Gneissose granites and gneisses are used as building stones and for road-metal in many parts of peninsular India, particularly in the Madras Presidency, for which returns have been available since 1910. Figures of production and value given are in Table 128.

From 1907 to 1908 there was a sudden increase in the Burmese production of granite and gneiss, from 27,781 tons to 340,939 tons. This was largely due to the development of quarries in gneissose granite in the Thaton district for the supply of stone to the Burma Railways Company and the Town Lands Reclamation Works in Rangoon. Owing probably to the same causes the production of the Thaton quarries is reported to have reached the enormous figure of 7,642,268 tons in 1909, valued at £344,704.[1] Since then the production from this district has been relatively small, but in 1909 quarrying began at Kalagauk Island in the Amherst district in connection with the Rangoon River Training scheme. The output in 1909 was 57,500 tons and with the introduction of a regular service of hopper barges, reached a total of 295,125 tons in 1912. With the completion of the scheme the works were closed down in 1914. From 1914, there was a steady rise up to 1917, and a somewhat sharp fall of 72,000 tons in 1918, from Burma. During the five years 1919-23 there was a still further fall, the annual average amounts working out to less than 116,000 tons; during the 1924-28 quinquennium this figure rose to nearly 638,000 tons, the annual average being 525,980 tons. The quinquennium under review commenced with an output of 631,273 tons for 1929 but this decreased to 187,652 tons in 1932, the average over the five years being 398,033 tons. The figures for other provinces show similar fluctuations but except in the cases of Burma and Madras, outputs are markedly larger than in the previous quinquennium. Kerb stones[2] of Mysore granite have recently found a market in London in competition with Scandinavian granite.

[1] The Government of Burma were unable to confirm this figure owing to the destruction of the district records.

[2] *Quarry and Road making*, XXXIX, No. 450, (March, 1934).

TABLE 128.—*Production of Granite and Gneiss during the years 1929 to 1933.*

—	1929		1930		1931		1932		1933		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Assam . .	30,302	*41,158*	15,863	*39,063*	10,304	*25,829*	6,973	*25,131*	8,339	*26,479*	14,356	*31,532*
Bengal . .	100,206	*73,796*	77,192	*1,37,661*	58,790	*43,335*	82,109	*52,918*	212,265	*1,45,359*	106,113	*90,614*
Bihar and Orissa.	251,544	*2,66,282*	431,785	*4,94,060*	449,978	*4,81,491*	408,779	*4,28,942*	464,891	*4,19,375*	413,395	*4,18,030*
Burma . .	631,273	*14,34,323*	443,018	*11,39,386*	313,047	*5,24,052*	187,652	*4,82,869*	415,175	*4,95,675*	398,033	*8,15,261*
Central Provinces.	30	*135*	7,407	*8,998*	29,008	*29,583*	37,250	33,196	13,695	*11,966*	17,478	*16,775*
Madras . .	10,317	*6,760*	192,127	*3,28,616*	211,203	*3,18,506*	157,464	*1,75,564*	130,274	*1,72,828*	140,377	*2,00,495*
Mysore . .	..	..	..	..	3,793	*92,453*	..	..	7,873	*2,84,742*	(a) 2,333	(a) *75,439*
Punjab . .	..	..	..	..	137,170	*1,50,614*	161.201	*1,65,205*	281,060	*2,49,153*	(a)115,886	(a)*112,994*
United Provinces.	..	..	..	..	..	..	45.630	*1,04,304*	52,890	*1,13,854*	(a)19,704	(a)*43,632*
TOTAL .	**1,024,172**	*18,22,454*	**1,167,392**	*21,47,984*	**1,213,293**	*16,65,863*	**1,147,058**	*14,68,129*	**1,586,462**	*19,19,431*	**1,227,675**	*18,04,772*
Total Value in sterling.		*£136,004* (£1 = Rs. 13·4)		*£159,110* (£1 = Rs. 13·5)		*£123,397* (£1 = Rs. 13 5)		*£110,386* (£1 = Rs. 13·3)		*£144,318* (£1 = Rs. 13 3)		*£134,643*

(a) Average of 5 years.

Sandstone.

The available figures for the production of sandstone in India are shown in Table 129. Those shown for the United Provinces refer to the output of Vindhyan sandstone from the Allahabad and Banda districts. The figures for Bihar and Orissa refer chiefly to the output of Vindhyan and Gondwana sandstones, from the districts of Shahabad and Manbhum respectively. A quartzite of good quality from Susunia Hill, Bankura, has been largely employed in Calcutta for paving and curb stones. Burma, in this quinquennium, with an average output of 189,000 tons, has displaced Rajputana as the leading producing province; sandstone is quarried in many districts, amongst which may be mentioned the Northern Shan States, Meiktila, Thaton, Minbu, Myingyan, Sagaing, Sandoway and Akyab. The next largest producer of sandstone was Rajputana, the annual output averaging a little under 180,000 tons; most of the stone was contributed by Alwar, Jodhpur, Bikaner and Dholpur States.

Limestone.

The subject of building materials naturally includes limestone and dolomite used as a building stone, and the two derived products, lime and cement. Limestone is also used as a flux in the smelting of iron-ore. In the present review cement is dealt with under a separate heading. Lime and cement are obtained, naturally, from the most conveniently situated deposits of limestones, such as those of the Upper Vindhyan series worked near Sutna in the Rewah State by the Sutna Stone and Lime Company, Ltd.; those of the Lower Vindhyan series worked at Katni in the Jubbulpore district by Messrs. Cook & Sons and others; those worked in the Cuddapah series at Bisra and Rourkela in Gangpur State by the Bisra Stone Lime Company, the material being mostly used as a flux in the iron and steel industry; or the various bands of crystalline limestones in Madras, Central India, and Rajputana, and the nummulitic limestones of Assam. The last-mentioned stone is brought down by boat during the rains from the southern scarp of the Khasi and Jaintia hills to Sylhet where it is burnt in primitive kilns; Calcutta at one time derived its main supply of building lime from this source. Vast quantities of limestone, suitable for building-stone or for lime-burning, are available over large areas of Baluchistan. Such figures as are available for the production of limestone during the period under review are given in Table 130.

TABLE 129.—*Production of Sandstone during the years 1929 to 1933.*

—	1929		1930		1931		1932		1933		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Assam . .	12,885	*36,856*	17,161	*49,261*	15,962	*27,007*	12,512	*20,309*	12,357	*21,955*	14,175	*31,176*
Bihar and Orissa.	39,029	*56,788*	72,233	*91,573*	48,927	*47,710*	20,285	*27,252*	33,830	*41,283*	42,861	*52,921*
Bombay .	8,909	*14,300*	..	..	..	..	..	..	..	..	(a)1,782	*(a)2,860*
Burma . .	309,554	*6,45,744*	264,461	*3,30,959*	176,930	*2,00,159*	107,175	*1,83,715*	87,097	*1,08,898*	189,043	*2,93,895*
Central India	5,985	*50,004*	6,809	*48,218*	8,451	*39,273*	2,025	*513*	..	..	(a)4,654	*(a)27,602*
Central Provinces.	13,900	*15,810*	..	..	..	..	..	..	..	..	(a)2,780	*(a)3,162*
Gwalior .	28,845	*49,795*	59,792	*50,056*	17,860	*26,815*	8,224	*14,796*	7,509	*11,599*	24,446	*30,613*
Mysore . .	..	..	11	*10*	1,085	*4,463*	525	*2,205*	..	..	(a) 324	*(a) 1,335*
Rajputana .	174,114	*4,34,178*	184,236	*7,82,050*	164,774	*6,18,464*	185,532	*6,57,775*	190,303	*6,44,281*	179,792	*6,27,350*
United Provinces.	40,398	*47,126*	10,450	*11,426*	2,641	*3,103*	3,263	*3,662*	15,967	*13,309*	14,544	*15,725*
TOTAL .	**633,619**	*13,50,604*	**615,153**	*13,63,553*	**436,630**	*9,66,994*	**339,541**	*9,10,727*	**347,063**	*8,41,325*	**474,401**	*10,86,641*
Total value in sterling.		*£100,791* (£1 = Rs. 13·4)		*£101,004* (£1 = Rs. 13·5)		*£71,629* (£1 = Rs. 13·5)		*£68,476* (£1 = Rs. 13·3)		*£63,257* (£1 = Rs. 13·3)		*£81,031*

(a) Average of 5 years.

TABLE 130.—*Production of Limestone and Kankar during the years 1929 to 1933.*

—	1929		1930		1931		1932		1933		AVERAGE	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Assam . .	60,724	*87,071*	67,788	*87,431*	41,085	*40,746*	53,551	*39,627*	65,464	*1,09,432*	57,722	*72,861*
Bihar and Orissa.	(*a*)889,499	*18,41,128*	(*c*)842,240	*18,50,494*	663,424	*13,58,764*	629,745	*12,52,565*	(*g*)705,598	*14,46,855*	746,161	*15,49,962*
Bombay .	224,850	*1,99,188*	147,624	*1,47,000*	45,656	*45,600*	..	..	128,260	*81,000*	(*i*)109,278	(*i*)*94,558*
Burma . .	239,769	4,88,625	269,534	*5,16,535*	442,817	*6,24,269*	184,196	*2,67,414*	377,439	*4,23,683*	302,751	*4,64,105*
Central India	123,274	*69,450*	116,907	*84,678*	96,460	*58,151*	118,816	*49,942*	113,569	*44,413*	113,807	*61,327*
Central Provinces.	447,802	*6,09,121*	424,579	*6,41,993*	362,746	*5,62,260*	289,253	*3,26,770*	634,316	*8,49,415*	431,739	*5,97,912*
Gwalior .	..	..	..	..	29,670	*20,014*	55,862	*32,853*	49,734	*23,330*	(*i*)27,053	(*i*)*15,239*
Kashmir .	..	..	676	*613*	..	..	..	..	..	..	(*i*)135	(*i*)*123*
Madras . .	18,375	*17,750*	16,459	*8,983*	13,215	*8,390*	19,640	*12,737*	13,826	*8,562*	16,305	*11,284*
Mysore . .	22,268	*36,430*	6,806	*26,285*	3,735	*22,808*	1,058	*5,812*	7,101	*21,500*	8,194	*22,567*
N.-W. F. Province.	1,061	*780*	14,474	*11,361*	7,709	*2,842*	2,349	*866*	996	*2,470*	5,318	*3,664*
Punjab . .	409,305	*5,25,936*	405,576	*5,46,812*	283,844	*3,47,071*	220,747	*2,49,310*	172,916	*1,58,568*	298,477	*3,65,539*
Rajputana .	(*b*)196,977	*3,03,794*	(*d*)211,328	*3,60,045*	(*e*)143,114	*2,17,384*	(*f*)182,046	*2,57,816*	(*h*)237,738	*3,85,677*	194,240	*3,04,943*
United Provinces.	718,538	*5,80,041*	773,485	*5,66,559*	754,128	*5,52,336*	243,821	*2,82,845*	636,079	*4,74,937*	625,210	*4,91,344*
TOTAL .	**3,352,442**	*47,59,314*	**3,297,476**	*48,48,789*	**2,887,612**	*38,60,635*	**2,001,084**	*27,78,560*	**3,1 3,036**	*40.29,842*	**2,936,330**	*40,55,428*
Total value in sterling.		*£355,173* (£1 = Rs. 13·4)		*£359,170* (£1 = Rs. 13·5)		*£285,973* (£1 = Rs. 13·5)		*£208,914* (£1 = Rs. 13·3)		*£302,996* (£1 = Rs. 13·3)		*£302,445*

(*a*) Includes 24,358 tons of dolomite. (*b*) Includes 206 tons of dolomite. (*c*) Includes 25,445 tons of dolomite. (*d*) Includes 15 tons of dolomite. (*e*) Includes 7 tons of dolomite. (*f*) Includes 87 tons of dolomite. (*g*) Includes 13,643 tons of dolomite. (*h*) Includes 97 tons of dolomite. (*i*) Average of 5 years.

The production of the Sutna Stone and Lime Company in Rewah has fallen to about half what it was during the post-War quinquennium. During the period under review unslaked lime manufactured by this company averaged 13,728 tons valued at Rs. 1,30,765, and slaked lime 956 tons valued at Rs. 2,235; both show an increase.

Besides the Maihar Stone and Lime Company, the Imperial Stone Lime Manufacturing Company is at present working limestone in the Maihar State. The annual output from that State showed an increase of 21 per cent. of what it was in the previous five years, and averaged 110,062 tons valued at Rs. 53,578, but the value was practically the same.

The production from Bihar and Orissa is derived chiefly from Gangpur State with, in some years, large amounts of *kankar* and limestone from the Shahabad district. The Gangpur output includes the production of the Bisra Stone Lime Company, of B. P. Byramji and Company, of the Gangpur Stone Lime Company, and of the Tata Iron and Steel Company. The average annual production of the Bisra Stone and Lime Company was 494,912 tons of limestone valued at Rs. 10,83,771, but hardly any dolomite- a notable increase in the case of limestone when compared with the production of the previous quinquennium. The Tata Iron and Steel Company produced 11,926 tons of dolomite, valued at Rs. 46,212, in 1933 and B. P. Byramji and Company produced an average of 24,825 tons of dolomite, valued at Rs. 74,476, in the years 1929 and 1930. In the other years of the quinquennium their dolomite production was unimportant and they produced no limestone. The Tata Iron and Steel Company were, during the quinquennium 1924-1928, using limestone as a flux in preference to dolomite. The percentage of insoluble matter in their limestone deposits, however, increased so much at depth that the material was found unsuitable as a flux for blast furnace purposes. The company therefore, closed down their limestone quarries, and are at present obtaining their requirements from the Bisra Stone and Lime Company.

Towards the end of the quinquennium 1909-1913 the opening of the Dehri Rohtas Light Railway led to the formation of three companies—the Kalianpur Lime Works, Limited, the Kuchwar Lime and Stone Company, Limited, and the Sone Stone and Lime Works —to work the Rohtas (Vindhyan) limestone at and near Banjari in the Shahabad district. These are still the three principal companies at work, but more than a dozen others are at present quarry-

ing limestone in this district. The total output of limestone in the Shahabad district, in which most of the workings have now come under the Indian Mines Act, averaged 233,442 tons valued at Rs. 4,14,936.

The production shown for the Central Provinces is derived mostly from Katni, where the limestone quarries come under the control of the Indian Mines Act. The quantity raised under this Act averaged 338,177 tons worth Rs. 3,95,974, compared with 366,288 tons valued at Rs. 5,05,149, for the previous quinquennium. The average daily labour employed is shown below separately for each year, the annual average for the period being 3,603 persons—a figure 873 short of that for the previous five-year period.

Production of Limestone from Katni Act-Mines and Labour Statistics.

—	Quantity.	*Value.*	Persons employed daily.
	Tons.	*Rs.*	
1929	341,244	*3,79,400*	3,753
1930	273,089	*3,07,218*	3,364
1931	232,841	*2,57,767*	2,348
1932	262,530	*2,80,279*	3,602
1933	581,180	*7,55,204*	4,946
Average .	338,177	*3,95,974*	3,603

A very small proportion of the limestone, shown as quarried in Assam, comes from the Lakhimpur district and Manipur, practically the whole of the output being from the Khasi and Jaintia hills, where the nummulitic limestone is being worked by the Sylhet Lime Company, Limited. The average output from this province amounted to 57,722 tons valued at Rs. 72,861 annually, a decrease of 22 per cent. on the amount of the average for the previous five years.

As regards the other areas reported as producing limestone the limestone of Burma comes from many localities, the most

important of which are the Amherst, Mandalay, Meiktila, Sagaing and Lower Chindwin districts, and the Northern Shan States. From Madras production is reported in small quantities in several districts, of which North Arcot and Tinnevelly are worth mentioning. The production reported from the Punjab comes mainly from the Attock, Jhelum and Rawalpindi districts, whilst the output reported from Rajputana comes chiefly from various States of which Bundi, Jodhpur and Sirohi are the most important. The production from the United Provinces includes *kankar*, which is used mostly for the metalling of roads instead of in the manufacture of lime. The production of *kankar*, averaged 609,036 tons annually. The output of limestone in the United Provinces averaged 16,174 tons, the more important districts being Dehra Dun, Etawah and Naini Tal.

Kankar.

One of the most widespread and interesting sources of lime is the material generally known by the name of *kankar*, some of the more solid varieties of which have found a limited use as building stone. The commonest mode of occurrence is in the great alluvial deposits, particularly in the older alluvium, in which the calcareous substances have segregated from the rest of the materials and have grown into irregular lumps like flints in chalk, including in the concretions a certain amount of the argillaceous substances which, when the *kankar* is burnt, is present in a proportion not far removed from that necessary to produce a hydraulic lime. The material of these concretions constitutes, in fact, a 'natural cement'.

Another industry for which a high-grade limestone is required is the manufacture of calcium carbide and calcium cyanamide. The latter is becoming increasingly important as a nitrogenous manure and a greater supply would in all probability create its own demand.

Laterite.

Laterite is widely distributed over the whole of the Peninsula of India and in Burma. In certain cases it has a special value as an ore of aluminium (*see* page 350), iron or manganese, according to composition (*see* page 244), but it is also very widely used as road-metal and as a building stone for culverts and buildings; for the latter purpose it possesses one advantage over other stones in the ease with which it can be cut into blocks and its power of subsequently hardening when exposed to the air. In most cases no statistics are collected. In Table 131 are given the statistics as far as available. The figures for Assam relate to Cachar and Sylhet and in some years to the

TABLE 131.—*Production of Laterite during the years 1929 to 1933.*

	1929		1930		1931		1932		1933		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Assam . .	28,665	*51,631*	37,617	*87,073*	18,440	*43,531*	19,129	*58,723*	34,366	*22.075*	27,643	*52,606*
Bihar and Orissa.	3,821	*4,073*	3,002	*701*	1,224	*477*	369	*143*	25	*10*	1,688	*1.082*
Bombay .	5,140	*4,320*	4,659	*4,589*	2,761	*3,462*	3,565	*6,043*	2,977	*3,971*	3,820	*4,477*
Burma . .	254,123	*3,65,489*	143,795	*2,13,490*	127,903	*2,04,726*	101,920	*1,86,768*	125,013	*1,44,636*	150.552	*2,23,022*
Central Provinces.	2,738	*6,253*	2,086	*3,946*	2,462	*4,974*	3,798	*7,385*	3,422	*6,247*	2,901	*5,761*
Madras . .	73.568	*81,231*	77,059	*87,905*	63,162	*60,263*	73,354	*67,796*	51,752	*44,400*	67,779	*68,319*
Mysore . .	6,798	*6,055*	11,058	*3,533*	214	*42*	159	*1,719*	590	*1,638*	3,764	*2,597*
TOTAL .	**374,853**	*5,19,052*	**279,276**	*4,01.237*	**216,166**	*3,17,475*	**202,294**	*3,28,577*	**218,145**	*2,22,977*	**258,147**	*3,57.864*
Total value in sterling.		*£38,735* (£1 = Rs. 13·4)		*£29,721* (£1 = Rs. 13·5)		*£23,517* (£1 = Rs. 13·5)		*£24,705* (£1 = Rs. 13·3)		*£16,765* (£1 = Rs. 13·3)		*£26,689*

Kamrup district, while those for Bihar and Orissa refer to the Puri district and the Nilgiri State. The annual Burmese output averaged 150,552 tons valued at Rs. 2,23,022. The output comes from some fifteen districts, but the most important are Amherst with an average annual output of 19,994 tons during the period, Insein with 26,524 tons and Thaton with 65,551 tons. The laterite of Madras comes from the East Godavery, Malabar and Chingleput districts, the last two contributing annually on an average 35,348 tons and 28,835 tons, respectively.

Gravel.

The mineral returns of Burma regularly give details of the production of gravel in various districts; the total figures are :—

						Rs.
1929		239,039	tons	valued	at	1,04,778
1930		216,754	„	„	„	81,750
1931		184,844	„	„	„	66,693
1932		183,924	„	„	„	79,762
1933		211,961	„	„	„	91,655
	Average	*207,304*				*84,927*

The most important districts are Mergui, Pakokku, Lower Chindwin, Shwebo, Sagaing and the Northern and Southern Shan States. The material is used for the repair of roads.

Cement.

[Cyril S. Fox.]

Impure limestones have long been used in India for the preparation of so-called ' natural cements ' but no records are available of these efforts. In 1904 cement was made from sea shells by the South India Industrials, Ltd., at Washermanpet, Madras. It is believed that cement has also been made by the Behar Lime and Cement Co., Ltd., of Jhajha, E. I. Ry., and by the Orissa Cement Co., Ltd., of Garh near Cuttack, but details of the product and output of these and similar works in various parts of India are not available. Previous to 1914, no true *Portland cement* according to the British Standards Specification, had evidently been made in India. In that year, the works of the Indian Cement Co. Ltd., Porbandar, Kathiawar, were erected. Since then, nine more Portland cement works have been erected at various places in India. Particulars of these companies are given below and details for most of them in the *Indian*

Concrete Journal, Volumes I, (1927) and II, (1928). This valuable monthly is published by the Concrete Association of India under the auspices of the Cement Marketing Co. of India, Ltd.; of this journal, Volume 8, No. 10, (October, 1934), is a special issue dealing with the Bihar Earthquake of the 15th January, 1934.

The Indian Cement Manufacturing Companies.

Name of Company.	Date when manufacture commenced.	Site of the works.	Full capacity of plant.	Fixed capital expenditure of the company, lakhs of rupees in 1925.	Amount of raw materials for one ton of cement.
			Tons.		
South India Industrials, Ltd.	1901	Washermanpet, Madras.	10,000	8·8	..
Indian Cement Co., Ltd.	1914	Porbandar, Kathiawar.	30,000	27·9 (In 1928, 38 ordinary and 1 debentures issued.)	1·3141 tons limestone, 0·1102 tons siliceous stone, 0·2757 tons clay.
Katni Cement and Industrial Co., Ltd.	1915	Katni, C. P.	60,000	47·5	About 1½ tons limestone and clay (latter only a small proportion).
Bundi Portland Cement, Ltd.	1916	Lakheri, Rajputana.	65,000	48·0	1·5 tons limestone, 45 lbs. gypsum.
Dwarka Cement Co., Ltd. (now Okha Cement Co., Ltd.)	1922	Dwarka, Kathiawar.	100,000	78·0	1·25 tons limestone, 0·4 tons clay.
Sono Valley Portland Cement Co., Ltd.	1922	Japla, E. I. Ry. (Daltonganj Branch).	50,000	77·0	..
Jubbulpore Portland Cement Co., Ltd. (now United Cement Co. of India, Ltd., from 1927).	1922	Mehgaon, near Jukehi, C. P., 10 miles from Katni	60,000	56·6	About 1·6 tons of limestone and clay (latter only a small proportion).
Gwalior Cement Co., Ltd.	1923	Banmor, 12 miles from Gwalior.	40,000	41·0	1·64 tons limestone 0 0125 tons clay.
Punjab Portland Cement, Ltd.	1923	Wah, near Hassan Abdal, Punjab.	36,000	61 2	1 ton limestone, ¼ ton clay, 0·05 tons gypsum.
Central Provinces Portland Cement Co., Ltd.	1923	Kymore, near Jukehi, C. P., 10 miles from Katni.	100,000	130·6	1½ tons limestone, 0·45 tons clay, 0·045 tons gypsum.
Shahabad Cement Co., Ltd.	1925	Shahabad, Hyderabad State.	80,000 (can be increased to 120,000).	In 1928, 50 authorised, 35 ordinary, and 12 debentures issued.	..
Okha Cement Co., Ltd.	..	(*See* Dwarka Cement Co., above.)	..	..	..
Dewarkand Cement Co., Ltd.	..	Roy, Ranchi District, Bihar.	..	..	..

NOTE.—The particulars in the above table are taken chiefly from the Report of the Indian Tariff Board on the Cement Industry 1924 and 1925.

Production.

The output of Portland cement in India during the period under review is given in Table 132. The steady increase in production is evident in Table 133, which also shows the equally regular falling off in the imports. It is remarkable that the enhanced output has been maintained even through the worst period of trade depression in 1931 and 1932.

TABLE 132.—*Production of Portland Cement in India during the years 1929 to 1933.*

——	1929	1930	1931	1932	1933	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Baroda	16,163	16,519	23,962	46,149	48,196	*30,264*
Bihar and Orissa	69,760	67,555	91,746	92,315	86,346	*81,544*
Bombay Presidency	25,101	25,681	23,347	12,258	17,316	*20,741*
Central Provinces	184,617	161,478	161,870	148,722	176,749	*166,687*
Gwalior	39,571	39,288	27,340	29,673	34,800	*34,134*
Hyderabad	72,263	89,948	131,808	128,939	99,287	*104,449*
Punjab	69,592	66,441	56,459	53,259	62,332	*61,617*
Rajputana	98,722	89,169	78,077	88,939	88,588	*88,699*
TOTAL	576,092	556,079	594,639	600,254	613,614	*588,135*

TABLE 133.—*Indian production and imports of Portland Cement for the 10 years 1924 to 1933.*

Year.	Indian production.	Imports.
	Tons.	Tons.
1924	263,746	124,286
1925	360,549	129,198
1926	375,993	99,967
1927	477,640	127,662
1928	558,544	135,574
1929	576,092	130,545
1930	556,079	120,797
1931	594,639	108,586
1932	600,254	82,422
1933	613,614	66,768

A new cement works was in course of erection at the close of 1933 about 4 miles west of Podanur in the Coimbatore district, Madras.

Prospects.

The excellent quality of the Indian-made Portland cements has overcome the earlier prejudice which existed among consumers when faced with the construction of very important structures. This was shown by its utilisation in the erection of the newly-opened Stanley Dam for the Cauvery-Mettur Reservoir project (*The Engineer*, CLVIII, August 31, 1934). The value of the industry is appreciated by Government and an import duty of Rs. 9 per ton on Portland cement (excluding white Portland cement) and of 15 per cent. *ad valorem* on cement excluding Portland cement (other than white Portland cement) has been imposed. It is unnecessary to discuss the modern methods of manufacture in rotary kilns, but it is necessary to say that the plant employed is quite up-to-date at most of the works and that the greatest care is taken in maintaining uniformity of quality and a high grade product. Excellent limestones are available at all the sites and the subject of suitable clay for admixture in the preparation of the cement has been fully examined. With the improvements which are taking place in building construction, not only of bridge piers and other engineering masonry and concrete structures, but in the numerous houses in villages as well as towns, a great future is assured for high grade cements of reasonable price. In fact better housing conditions and the construction of excellent roads are being made possible by cements owing to the long life which such buildings and roads must have as compared with the older materials. Coloured cements have also permitted of a degree of ornamental work at moderate cost which was not possible before.

Aluminous cement.

Mention must here be made of *ciment fondu* or aluminous cement which is being made in increasing quantities in Europe and the U. S. A. by fusing a mixture of bauxite and limestone. The product of the fusion when crushed and ground to the requisite fineness is a high-grade, rapid-hardening cement which is particularly suitable for use in the presence of salt and sulphate waters (*see* paper by A. Virian Hussey, *Journ. Soc. Chem. Industry*, Vol. 53, October 12, 1934). These high-priced cements are at present largely used for special purposes where the conditions justify the extra cost. N. V.

S. Knibbs ('Industrial Uses of Bauxite,' pages 70-91, 1928) has discussed these cements fairly fully, and the question of a British Standard Specification was under consideration a few years ago (*The Structural Engineer*, November, 1930). Small scale experiments in India have shown, according to tests on samples supplied to the Government Test House, Alipore, that the same kind of cement can be made by fusing aluminous laterite and limestone (*see* Indian Patent, Specification No. 18911, 27th April, 1932, 'Improvements in or relating to the manufacture of cement and the recovery of iron in such manufacture'). There seems to be no reason why such a cement should not be made in India for the same purposes as *ciment fondu* and at a more reasonable price.

Clays.

[A. M. HERON.]

Importance of clay as a mineral product.

The important part played by clay in the industrial development of a country is not generally recognised, but can easily be illustrated by reference to the mineral statistics of such an industrially advanced country as the United Kingdom. In 1933, clay ranked second in value amongst the mineral products of that country; the output in that year being 20,812,624 statute tons valued at £2,886,172. The figures, in 1922, for the United States relate only to the manufactured products but reach the total value of £72,572,100. The magnitude of this total can be grasped when it is pointed out that this was more than three times the value of the total Indian mineral output for the same year of all minerals for which reliable statistics were available.

Production in India.

No statistics approaching any degree of completeness are obtainable to show the extent of the undoubtedly great industrial value of the clays in India. Figures for the production during the last quinquennium show a great increase over those of the previous period. These figures include the finer varieties of clay used for glazed pottery; fire-clays raised in considerable quantities on some of the Gondwana coal-fields; fuller's earth, which is mined in the Central Provinces, Mysore and Rajputana; and China clay which is produced mainly in Bihar and Orissa, Mysore and Jubbulpore. How incomplete

these figures must be can be understood when it is realised that there is hardly a village in India without its local potter, who provides every household with cooking utensils, water-vessels and other hollow-ware articles made on the potter's wheel, and that near practically every large village in India there exists a brickfield which supplies the needs of the locality. No returns of the clay used in these local manufactures are available.

The valuable paper entitled 'Indian Earths, Pottery Clays and Refractory Materials' by Mr. W. H. Bates[1] may be consulted for details of the composition and manufacture of Indian clays.

The output of clay for which returns are available is summarised in Table 134. From this it will be seen that the average annual output during the period 1929-1933 has been 247,305 tons valued at Rs. 3,61,614; during the previous quinquennium the average annual output was 151,901 tons valued at Rs. 3,44,231.

The Bengal output is derived mainly from the Burdwan district, where Messrs. Burn and Company's factory at Raniganj provides occupation for nearly 2,500 employees and turns out goods of various descriptions, amongst which the most important are glazed stoneware drain pipes and roofing and flooring tiles. The manufacture of refractories such as fire-bricks and silica bricks also forms an important branch of their industry. Fire-bricks and roofing tiles are also manufactured at the Kumardhubi fire-clay and silica works of Messrs. Bird and Company near Barakar, by Messrs. Andrew Yule and Company at Chanch and at the Bengal Firebrick Syndicate of Messrs. Martin and Company at Kulti in the same vicinity; in the Madras Presidency the Commonwealth Trust, Ltd., the Madura Co., Ltd., and Harrisons and Crossfield, Ltd., carry on the same manufacture. During the ten years 1923-24 to 1932-33 over forty-seven and a half million pieces of tiles were exported from the Madras Presidency as an annual average, with an average value of Rs. 21,93,310.

The output of the Central Provinces is mainly from the Jubbulpore district with a small production from the Hoshangabad district. The main portion of the Jubbulpore output is derived from quarries in the Upper Gondwana rocks near Jubbulpore town and is used in the pottery works of Messrs. Burn and Company and the Perfect Pottery Company. A certain amount of clay is also won by the Katni Cement and Industrial Company at Tikuri near Katni.

[1] *Trans. Min. Geol. Inst. Ind.*, Vol. XXVIII, Pt. 2, pp. 103-160, (1933).

TABLE 134.—*Production of Clay in India during the years 1929 to 1933.*

	1929		1930		1931		1932		1933		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Assam . .	..	..	..	..	19,486	*19,486*	6,495	*29,238*	4,139	*4,140*	(a) 6,024	(a) *10,573*
Bengal . .	35,964	*73,177*	31,539	*54,925*	22,005	*33,155*	12,487	*24,413*	8,296	*6,249*	22.058	*38,384*
Bihar and Orissa.	27,131	*2,67,203*	30,731	*1,94,251*	22,501	*1,87,576*	20,898	*1,08,028*	32,319	*1,08,650*	26,716	*1,73,142*
Burma . .	23,026	*38,009*	25,573	*32,056*	20,825	*28,178*	21,788	*24,914*	19,365	*23,615*	23,115	*29,354*
Central India	938	*3,126*	1,817	*5,934*	1,045	*3,620*	..	..	404	*1,500*	(a) 841	(a) *2,836*
Central Provinces.	119,227	*54,428*	48,721	*39,440*	27,240	*20,571*	27,396	*29,176*	50,424	*25,420*	54,602	*33,807*
Delhi . .	2,310	*1,560*	3,864	*3,504*	2,553	*1,936*	..	..	5,342	*3,038*	(a) 2,814	(a) *2,007*
Gwalior .	445	*3,185*	534	*2,500*	377	*1,459*	378	*1,365*	462	*1,730*	439	*2,048*
Kashmir .	..	..	11	*11*	11	*11*	11	*12*	18	*34*	(a) 10	(a) *14*
Madras . .	20,106	*2,058*	1,367	*495*	5,196	*2,705*	3.102	*1,005*	182,588	*70,222*	42,472	*15,297*
Mysore . .	88,219	*95,138*	28,370	*37,686*	23,640	*29,552*	17,450	*25,558*	70,332	*30,760*	45,602	*43,739*
Punjab . .	39,079	*5,058*	4,213	*607*	11,852	*1,852*	16,089	*2,514*	25,347	*3,960*	19.316	*2,804*
Rajputana .	2,383	*1,552*	3,579	*10,430*	4,237	*11,391*	4,790	*12,478*	1,489	*2,195*	3.296	*7,609*
TOTAL .	**363,828**	*5,44,524*	**180,319**	*3,81,839*	**160,968**	*3,41,492*	**130,884**	*2,58,701*	**400,525**	*2,81,513*	**247,305**	*3,61,614*
Total Value in Sterling.		*£40,636* (£1 = Rs. 13·4)		*£28,284* (£1 = Rs. 13·5)		*£25,296* (£1 = Rs. 13·5)		*£19,451* (£1 = Rs. 13·3)		*£21.167* (£1 = Rs. 13·3)		*£26,967*

(a) Average of five years.

Fire-clays.

Fire-clays used in the manufacture of refractories are worked near Barakar in Bengal, and in Bihar and Orissa in the same neighbourhood, near Jubbulpore in the Central Provinces and in the vicinity of the Kolar Gold Fields in Mysore. A new locality is that of Ratucha, near Khewra in the eastern Salt Range, where a fire-clay seam five and half feet in thickness is worked below the Eocene coal by Messrs. Lahore Industrials Ltd. It has been very favourably reported on by Prof. J. W. Mellor, whose analysis is given below.

	Per cent.
SiO_2	44·08
TiO_2	2·50
Al_2O_3	38·48
Fe_2O_3	0·88
MgO	0·09
CaO	0·02
K_2O	0·02
Na_2O	0·14
Loss over 109°C	13·72
	99·93

China clay.

India also possesses resources in China clay or kaolin. This is used extensively in industry for the making of high-grade pottery, cotton dressing, paper filling, soap making, paint mixing, rubber manufacture and in medicines. Its value for purposes other than pottery lies mainly, when properly refined, in its perfect whiteness, fineness, so-called colloidal properties and its harmlessness when used edibly. The China clay and fire-clay deposits of the Rajmahal hills were investigated by Dr. Murray Stuart[1] who reported most favourably on their suitability for manufacturing porcelain and fire-bricks of the highest quality. The Calcutta Pottery Works have used kaolin from Mangal Hat in the latter area and have succeeded in producing cups, saucers, jugs and ornaments of common white porcelain. Mr. F. B. Kerridge[2] in a paper on 'The Working and Refining of Indian Kaolin with special reference to a Singhbhum deposit,' gives the following tables showing the results of a number of analyses made of samples of

[1] *Rec. Geol. Surv. Ind.*, XXXVIII, pp. 133-148, (1909).
[2] *Trans. Min. Geol. Inst. Ind.*, Vol. XXIV, pp, 295-320, (1930).

China clay taken at random from ordinary consignments received from Cornwall, and of samples of clay prepared at the Kasimbazar mines at Hat Gumaria, 30 miles south of Chaibassa in the Singhbhum district of Bihar and Orissa. Mr. Kerridge observes that—

'chemically the Indian clay compares favourably with the English variety except in regard to lime and magnesia content, but that so far as alumina and combined silica are concerned, there is but little difference in the two clays.'

Sample No.	Alumina.	Oxide of iron.	Lime.	Magnesia.	Combined silica.	Insoluble silica.	Moisture and water of hydration.
English Imported Clays.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1 . . .	36·53	1·17	0·20	0·36	42·01	7·05	12·51
2 . . .	38·87	1·30	0·25	0·54	45·17	1·70	12·08
3 . . .	37·02	1·60	0·20	0·36	46·07	1·66	12·69
4 . . .	35·88	1·57	0·30	0·36	45·42	3·63	12·20
5 . . .	35·49	1·21	0·30	0·29	46·55	2·52	13·30
6 . . .	35·35	0·85	0·40	0·51	45·48	4·63	12·21
Average .	*36·52*	*1·28*	*0·27*	0·40	*45·11*	*3·53*	12·49
Singhbhum Clays.							
1 . . .	37·13	0·67	0·71	0·79	43·28	3·68	13·39*
2 . . .	37·13	0·57	0·66	1·02	44·19	4·32	11·10
3 . . .	35·58	1·22	0·96	0·90	43·25	7·05	10·29
4 . . .	38·27	1·03	1·03	0·55	43·86	4·90	10·13
5 . . .	34·26	1·24	1·13	0·52	43·01	4·84	14·38*
6 . . .	35·05	0·62	0·68	0·12	46·88	4·52	11·76
Average .	*36·28*	*0·89*	*0·86*	*0·65*	*44·07*	*4·88*	*11·48*

* These two samples were obviously not 'Dry' when analysed.

For paper filling, the Singhbhum product has completely cut out the imported China clay in the paper mills managed by Messrs. Bird and Company in the Calcutta vicinity, in which mills over 3,000 tons of China clay are used per annum. A considerable amount of clay of a light pink colour but remarkable purity, from the same locality, has also been used successfully in the Calcutta Pottery Works for 'stoneware' acid jars.

Mr. D. P. Chandoke[1] has described the working of kaolin from pegmatite at Kasumpur, five miles south of New Delhi. This

[1] *Trans. Min. Geol. Inst. Ind.*, Vol. XXVII, Pt. 4, pp. 279-300, (1933).

TABLE 135.—*Production of China Clay in India during the years 1929 to 1933.*

	1929		1930		1931		1932		1933		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
Bihar and Orissa—	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Bhagalpur .	4,082	*52,877*	434	*1,170*	180	*3,430*	525	*1,125*	19	*95*	1,048	*11,739*
Singhbhum .	5,336	*1,27,655*	9,212	*97,469*	14,816	*1,49,053*	9,120	*79,814*	10,530	*52,856*	9,803	*1,01,369*
Burma—												
Thaton .	..	..	..	..	..	..	..	..	391	*49*	(*a*) 78	(*a*) *10*
Central India .	938	*3,126*	1,817	*5,934*	1,045	*3,620*	..	..	404	*1,500*	(*a*) 841	(*a*) *2,836*
Delhi . .	2,310	*1,560*	3,864	*3,504*	2,553	*1,936*	..	..	5,342	*3,038*	(*a*) 2,814	(*a*) *2,008*
Gwalior .	445	*3,185*	534	*2,500*	377	*1,459*	378	*1,365*	462	*1,730*	439	*2,048*
Madras—												
Cuddapah .	275	*290*	407	*405*	1,381	*1,402*	700	*688*	1,009	*1,010*	755	*759*
Mysore .	3,271	*21,558*	2,846	*18,660*	2,613	*18,590*	2,113	*13,800*	2,938	*19,538*	2,756	*18,429*
Rajputana—												
Ajmer-Merwara	..	..	2	*56*	400	*400*	650	*650*	840	*840*	(*a*) 378	*389*
TOTAL .	**16,657**	*2,10,251*	**19,116**	*1,29,698*	**23,365**	*1,79,890*	**13,486**	*97,442*	**21,935**	*80,656*	**18,912**	*1,39,587*

(*a*) Average of 5 years.

is used for fire-bricks, tiles, crockery, pipes, insulators, etc., at the Gwalior Potteries, Ltd. works at Safdarjang, three miles away. China clays are used by the pottery works at Than Junction, Kathiawar.

Production of China clay.

Table 135 shows the production of China clay in India during the quinquennium under review. The most striking feature brought out by this table is the average figures for Bihar and Orissa, 10,851 tons valued at Rs. 1,13,108 with an average value of Rs. 10 as. 7 per ton, against an average total production of 8,061 tons valued at Rs. 26,479 giving an average value of Rs. 3 as. 4 per ton for the rest of India. The high value of the kaolin from Bihar and Orissa is due to the cost of the levigation processes to which the clay is subjected before being sold for paper filling, soap making, paint mixing and other of the more refined uses for which it can be utilised. The steady advance made by the China clay of Bihar and Orissa is brought out on comparing these production figures with those recorded in the previous review. A production of 2,749 tons in 1924 steadily increased to a maximum of 10,458 tons in 1927, only to fall in 1928 to 7,186 tons, rising again to 14,996 tons in 1931.

In Table 136 will be found the imports of China clay into India by provinces. The advance of the Bihar and Orissa industry is reflected in the decrease in imports of China clay into Bengal since 1925-26. Up to 1926-27 the imports of China clay into India steadily advanced but since then the general tendency has been downward and the annual average for the quinquennium under review is 5,282 tons less than that for the previous one. This decline may, if the Indian producers keep up the quality of the refined product, be the harbinger of a greater decline in the future when, there seems little doubt, the Bihar and Orissa China clay will completely oust the Cornish clay for all purposes in the Bengal market.

Fuller's earth.

Fuller's earth is obtained at Katni in the Jubbulpore district of the Central Provinces where it occurs in the Lower Vindhyan series. A form of fullers' earth is also worked in the States of Bikaner and Jodhpur in Rajputana and in the Khairpur State and Hyderabad district in Sind; this and other varieties are eaten in various parts of India.

In Table 137 will be found the production of fullers' earth in India for the quinquennium under review. The average annual production is 7,621 tons valued at Rs. 75,083 and shows a marked increase over the figure for the previous quinquennium, which was

TABLE 136.—*Imports of China Clay into India during the years 1928-29 to 1932-33.*

	1928-29		1929-30		1930-31		1931-32		1932-33		AVERAGE.	
—	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Bengal . .	3,374	*2,10,493*	2,864	*1,94,913*	1,999	*1,34,136*	1,344	*77,800*	1,019	*64,999*	2,120	*1,38,265*
Bombay .	11,467	*7,36,730*	21,840	*12,93,894*	9,924	*5,68,134*	18,181	*8,24,486*	16,938	*7,45,465*	15,670	*8,33,742*
Sind . .	..	..	(*a*)	*15*	9	*701*	6	*602*	14	*1,705*	6	*604*
Madras . .	97	*11,203*	224	*22,156*	54	*5,167*	151	*10,899*	81	*5,551*	121	*10,995*
Burma . .	..	.	22	*4,368*	1	*73*	2	*356*	59	*14,916*	17	*3,943*
TOTAL .	**14,938**	*9,67,426*	**24,950**	*15,15,346*	**11,987**	*7,05,211*	**19,684**	*9,14,143*	**18,111**	*8,32,636*	**17,934**	*9,87,552*

(*a*) 5 cwts.

TABLE 137.—*Production of Fuller's Earth during the years 1929 to 1933.*

	1929		1930		1931		1932		1933		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Bombay—												
Hyderabad (Sind)	831	*7,066*	909	*3,089*	473	*10,453*	789	*13,416*	688	*14,035*	738	*9,612*
Khairpur State (Sind)	3,037	(a) *30,370*	4,251	(a) *42,510*	4,785	(a) *47,850*	3,527	(a) *35,270*	4,182	(a) *41,820*	3,956	*39,564*
Central Provinces—												
Jubbulpore	63	*309*	19	*93*	38	*156*	19	*93*	35	*221*	35	*150*
Mysore State	695	(b)	280	*294*	..	..	..	..	..	..	(c)195	(c)*59*
Rajputana—												
Bikaner State	..	..	1,754	*10,582*	1,146	*8,098*	2,193	*15,493*	1,491	*10,532*	(c)1,317	(c)*8,941*
Jaipur State	85	*500*	..	..	..	..	..	..	..	..	(c)17	(c)*100*
Jaisalmer State	20	*310*	19	*276*	15	*178*	16	*180*	17	*191*	17	*227*
Jodhpur State	1,400	*17,500*	1,450	*18,000*	1,286	*15,400*	1,342	*16,100*	1,250	*15,000*	1,346	*16,400*
TOTAL	6,131	*56,055*	8,682	*74,844*	7,743	*82,165*	7,886	*80,552*	7,663	*81,799*	7,621	*75,083*
Total value in Sterling		*£4,183* (£1 = Rs. 13·4)		*£5,544* (£1 = Rs. 13·5)		*£6,086* (£1 = Rs. 13·5)		*£6,057* (£1 = Rs. 13·3)		*£6,150* (£1 = Rs. 13·3)		*£5,604*

(*a*) Estimated. (*b*) Not available (*c*) Average of 5 years.

3,169 tons valued at Rs. 21,706. In the quinquennium under review, Khairpur State appeared as the leading producer with an annual average of 3,956 tons. Jodhpur and Bikaner increased their production over that of the last quinquennium, Hyderabad district (Sind) became an important producer, and the Mysore output decreased to a fifth of that recorded in the previous five years.

Imports.

The imports of materials coming under this section—namely earthenware and porcelain, earthenware piping, bricks and tiles and clay are shown in Table 138, from which it will be seen that they decreased during the period under review. The average annual value of these imports was Rs. 68,27,392 as compared with Rs. 1,04,51,343 during the preceding five years, a decline of just under 34 per cent. as compared with 8 per cent. between the two previous periods.

TABLE 138.—*Value of imports into India of Clay and Clay Products during the years 1929-30 to 1933-34.*

Year.	Earthenware and porcelain.	Earthenware piping.	Bricks and tiles.	Clay.	Total annual Imports.
	Rs.	Rs.	Rs.	Rs.	Rs.
1929-30 . . .	72,01,387	32,198	28,86,932	78,576	1,01,99,093
1930-31 . . .	47,87,313	28,826	17,04,076	65,072	65,85,287
1931-32 . . .	38,30,167	5,888	14,17,103	48,452	53,01,610
1932-33 . . .	49,50,135	5,902	13,61,283	48,580	63,65,900
1933-34 . . .	43,06.322	8,595	13,28,340	41,813	56,85,070
Average .	*50,15,065*	*16,282*	*17,39,547*	*56,498*	68,27,392

As the average value of the exports and re-exports of clay and clay products during the period has amounted only to Rs. 6,78,083, the total Indian consumption of such products exceeds the internal production by Rs. 61,49,309, indicating considerable scope for the development in the country of industries making use of clay.

Cobalt.

[A. M. HERON.]

Cobaltite, a sulph-arsenide of cobalt, and danaite, a cobaltiferous arsenopyrite, have been found as minute crystals disseminated amongst the slates of the Aravalli series at Khetri[1] and other places in Rajputana. These ores have been used for the manufacture of various sulphates. The minerals were formerly separated for the production of *sehta*, which is used by the Indian jewellers for producing a cobalt-blue enamel. The sulphide of cobalt, linnæite (Co_3S_4), has been identified in the Geological Survey laboratory amongst some ores of copper sent a few years ago from Sikkim by Colonel Newcomen. Some years ago specimens of a matte containing 11 to 14 per cent. of cobalt, the rest being iron and sulphur, were received in the Geological Survey office from Nepal, but no details as to the mode of occurrence have ever been forthcoming; the matte is reported to have come from Kachipatar Argah, *zillah* Sowrobhar, about 80 miles north of Doolha.[2] Small quantities of cobalt and nickel are frequently detected in the Indian manganese ores; the best sample is the cobaltiferous wad of Olatura in the Kalahandi State, a specimen of which yielded 0·82 per cent. of cobalt oxide (CoO).

Since 1927, there has been a regular production of nickel-speiss as a by-product in the smelting operations of the Burma Corporation, Limited, at Namtu in the Northern Shan States of Burma. This speiss, of which the average production was 3,211 tons annually during the period under review, contains from 3 to 4 per cent. of cobalt, and is shipped to Hamburg for further treatment (*see* Nickel).

Corundum.

[A. M. HERON.]

The use of abrasives in manufacturing communities is still on the increase, and new artificial forms are frequently being put on the market. Emery formerly served most requirements, until purer forms of corundum were discovered in quantity. The cheaper forms of garnet have long been used to adulterate emery, and

[1] *Rec. Geol. Surv. Ind.*, XIV, pp. 190—196, (1887); *see* also A. M. Heron, *op. cit.*, XLIV, p. 19, (1914).

[2] E. J. Jones, *Rec. Geol. Surv. Ind.*, XXII, p. 172, (1889).

members of the spinel family, such as hercynite, have been used inadvertently as such. During the last forty years carborundum, manufactured by the cheap electrical power developed in America, has come into use, the production of the United States having now reached an average figure of over 20,000 short tons a year. Artificial forms of corundum are being manufactured from bauxite and the use of artificial aluminous abrasives continues to grow; the annual output of artificial alumina in the United States has, on two or three occasions, exceeded 50,000 short tons.

Crushed steel is being used to a steadily increasing extent.

Natural corundum has thus several competitors in the market of abrasive materials, and as a large portion of the alumina in igneous magmas is necessarily used up during the processes of consolidation by the silica and bases present, it is theoretically unlikely that the free oxide can exist anywhere in an abundance comparable to the vast quantities of combined alumina in the earth's crust. In most cases the corundum is scattered as isolated crystals through the rock, and only the most economical devices for its separation can make mining remunerative. Manufactured abrasives shew a general superiority over natural corundum, and the outlook for the latter industry is not encouraging.

In India, where the use of corundum by the old *saikalgar* (armourer) and lapidary has been known for many generations, the requirements of the country have been met by a few comparatively rich deposits, but it is doubtful if these are worth working for export in the face of the competition referred to above in Europe and America, or will even stand against the importation of cheap abrasives.

There is still, and for many generations has been, a certain trade in Indian corundum, but the returns for production are manifestly incomplete. No workings exist of the kind that could be ordinarily described as mining, but attempts have been made at times to increase the scale of operations at Palakod and Paparapatti in the Salem district of Madras, near Hunsur in Mysore, and in South Rewah.

Production.

The occurrence near Pipra in Rewah State was worked some years ago by Indian traders of Mirzapur. A peak production of 1,860 cwts. was obtained in 1913, but the supply fell to an average of nearly 400 cwts. during 1914-1918. In 1919, it again rose to 1,471 cwts. followed

by 882 cwts. in the following year, but the mines have not been worked since 1920. Small quantities of corundum were produced in the Bhandara district of the Central Provinces in 1925, 1926 and 1927. Of the production of corundum recorded from the Madras Presidency, 211 cwts. from Coimbatore and 478 cwts. from Trichinopoly made up the supply for 1914, but throughout the remainder of the period (1915-1918) the whole of the output, averaging 31½ cwts. annually, came from South Kanara. During the quinquennium 1919-1923, there was no output from Madras. In 1926, 1927, 1928, 1929 and 1930 outputs of 17, 52, 21, 34 and 30 tons were reported from the Salem district, but since then no production has been recorded.

Corundum is very widely distributed throughout the Mysore State and is said to occur in every district except Shimoga. In 1914, the output came from Kolar, in 1915, from Kolar (76 cwts.) and Tumkur (843 cwts.), and in 1916, from the Mysore district. The average annual production during the quinquennium 1914-1918, was 523 cwts. valued at Rs. 1,560; there has been no recorded output for the past fifteen years.

Much of the corundum which is a regular item of trade in the bazars of cities like Delhi, Agra, and Jaipur, where the Indian lapidary still flourishes, is collected in a casual way by agriculturists and cowherds, who dispose of it through the village *bania* to the larger dealers of the great cities. Our information as to the mode of occurrence and distribution of the mineral was summarised in a special memoir by Sir Thomas Holland published by the Geological Survey in 1898.

The production of corundum with sapphire in Kashmir State amounted to 1·6 cwts. in 1926, 11 cwts. in 1927, 1 cwt. in 1928 and 5·7 cwts. in 1933. The mines are situated near Sumjam (Sumsam) in the Udhampur district, Jammu Province, and are under the direct control of the Mineral Survey Department of the State. Production is also reported from Mahbubnagar, Gulbarga, and Nalgonda in Hyderabad.

Khasi Hills.

Corundum (*mawshinrut*) is known to occur at three localities in the Nongstoin State in the north-west Khasi hills, but much of the material obtained in this province in recent years is now known to be sillimanite (*q. v.*). The localities have, so far, proved to be too difficult of access for the exploitation of either mineral on a large scale, but

corundum is worked in small quantities and used all over the Khasi hills for hones.[1] The reported output of corundum from the Khasi hills was 12,660 cwts. in 1919, 3,320 cwts. in 1920, and 1,277·6 cwts. in 1921, but it is not known what proportion of this was sillimanite. No production of corundum is reported for the last twelve years.

Gem varieties of corundum are treated under 'Ruby and Sapphire' (*see* page 280).

The chief producers of corundum and emery used to be Canada, Turkey and Greece, Canada supplying corundum, and Turkey and Greece emery. The Canadian corundum is found in Ontario in association with nepheline-syenite like that near Kangayam in the Coimbatore district[2]. By the adoption of mechanical means for concentration it became possible to separate corundum from the felspar-rock in which it was embedded, and to put a product on the market, not only for local use, but for export to the United States and Europe. The Canadian industry commenced in 1900, and the annual production for the five years 1914-1918 averaged 240 tons valued at £6,876, an output which was less than one-sixth of what it had been before the war. The production of corundum in Canada ceased after the war, the last shipments to the United States, which is the largest consumer of the material, having been made in 1921. The world' principal source of supply to-day is the Zoutpansberg and Pietersberg districts of the Transvaal where the mineral occurs mainly as loose crystals in shallow eluvial deposits. In 1926, the Transvaal furnished nearly 6,000 short tons of corundum, but in 1933 only 1,304 tons (sales.)

Canadian corundum.

Fluor-spar.

[A. M. HERON.]

Fluor-spar has been obtained at Barla in the Kishengarh State, Rajputana, but the work of excavation was abandoned under a mistaken impression that the mineral was an inferior form of amethyst. Apparently the mineral here forms, with calcite and quartz, a vein about a foot in thickness traversing gneiss. This

[1] F. E. Jackson, *Rec. Geol. Surv. Ind.*, XXXVI, p. 323, (1908).

[2] T. H. Holland, 'The Sivamalai series of Elæolite and Corundum-Syenites,' *Mem. Geol. Surv. Ind.*, XXX, Pt. 3, (1901).

occurrence was investigated by the Tata Iron and Steel Company, who reported that very little fluor-spar was present, and that the cost of working it would exceed that at which they are able to purchase it from Europe; their imports of fluor-spar for use as a flux in the manufacture of steel during the five years under review were as follows:—

	Tons.
1929	332
1930	438
1931	435
1932	475
1933	750

Imports during the previous period averaged 953 tons a year.

Fluor-spar has also been found as small crystals in a dyke of quartz-porphyry near the copper-ore lodes of Sleemanabad, Jubbulpore district[1]; another occurrence in the Central Provinces is known at Chicholi in the Drug district, where fluor-spar accompanies galena and copper carbonate in a quartz vein traversing gneiss[2]. Other localities recorded for the mineral are: near Rewah[3] in one of the Vindhyan limestones; in the granitic veins of the Sutlej valley, North-West Himalaya[4]; and in limestone in the Amherst district, Burma. Fluorite was found associated with orpiment and realgar at Mirgasht Gol in the Tirich valley, Chitral. It has also been observed in a joint in carbonaceous (Barakar shale adjoining a decomposed dolerite dyke in the neighbourhood of Rawanwara, Chhindwara district, Central Provinces. No indication of large deposits has been noticed at any of the localities.

Garnet.

(*See* 'Gem-stones of lesser importance'.)

Gem-stones of lesser importance.

[A. M. Heron.]

The most valuable of the precious stones raised in India is undoubtedly the ruby, but this and the other stones obtained in

[1] L. L. Fermor, *Rec. Geol. Surv., Ind.*, XXXIII, p. 63, (1906).
[2] W. T. Blanford, *op. cit.*, III, p. 44, (1870).
[3] F. R. Mallett, *Mem. Geol. Surv. Ind.*, VII, p. 122, (1871).
[4] F. R. Mallet, *op. cit.*, V, p. 166, (1866).

the country do not approach in value the unset stones and pearls imported, which, during the period under review, had an average annual value of Rs. 76,58,788 (compared with Rs. 1,19,02,603 during the previous quinquennium).

Of the precious and semi-precious stones in India, the most important, amber, diamond, jadeite, ruby, sapphire, and spinel, have been already referred to. Of the others, the only ones that are of immediate concern are agate, rock-crystal, beryl, garnet, tourmaline, and turquoise. All of these except the last have been or are still being worked to some extent in India; the turquoise may be dismissed with the mere mention of the fact that India, besides being a large importer for local use, is one of the channels by which the material raised in Persia and adjoining areas reaches the European and Eastern market. The other minerals—with some other Indian stones at present used very little or not at all—deserve more particular mention.

Agate.

Up to about twenty years ago there had been a considerable trade in agate and the related forms of silica, carnelian, onyx, etc., known under the general name of *hakik*, and obtained from the amygdaloidal flows of the Deccan trap. The best known and most important of the places at which agate and carnelians have been cut and prepared for the market is Cambay, the chief city of the State of that name under the Gujarat States Agency, Bombay Presidency. The agates come from various States and districts on or near the edge of the trap, the chief sources of supply being the Kistna, Godavari, Bhima, Narbada and other rivers draining trap-covered areas. A large proportion of the pebbles comes from the State of Rajpipla. An account of the Rajpipla agate industry has been given by Mr. P. N. Bose.[1] The agates occur in a conglomerate of probable Pliocene age, and have been worked chiefly at Ratanpur and Damlai. The stones are chipped at the mines, and those approved of taken to Limodra, where they are baked. The baked stones are sent to Cambay for cutting and polishing. The Rajpipla *hakik* mines are leased for periods of five years at a fixed annual rental or royalty. This was Rs. 3,000 a year for the period 1902-06. No precise data as to the value of the stones sent to Cambay are available. The Rajpipla mines have not been worked since 1917 except in 1929, when 148·7 cwts., valued at Rs. 8,000, (£597) were raised.

[1] *Rec. Geol. Surv. Ind.*, XXXVII, pp. 176—182, (1908).

A certain amount of agate-cutting is also carried on at Jubbulpore in the Central Provinces, at Banda in the United Provinces, and at a few other places within range of the Deccan trap. Much of the agate retailed in Europe is sent from Cambay, and large quantities are also exported to China from that city.

Various forms of quartz—rock-crystal, amethyst, etc.—are used by jewellers in various parts of India.

Rock-crystal.

In the Tanjore district, Madras Presidency, fragments of rock-crystal are collected and cut for cheap jewellery, being known as 'Vallum diamonds', whilst the bipyramidal quartz-crystals, found in the gypsum of the Saline series near Kalabagh and Mari, on the Indus, are to a certain extent used for making necklaces; these crystals are sometimes known as 'Mari diamonds'. Rock-crystal is similarly used for cheap jewellery in Kashmir. Fine pieces of rock-crystal are sometimes cut into cups, sword handles, and sacred objects, such as *lingams*, in Northern India. An exceptionally fine crystal of transparent quartz came to light in Burma in 1925. A ball 30 inches in diameter and 130 lbs. in weight was cut from the mass in China, polished in Japan and found its way to the United States National Museum at Washington. The crystal is presumed to have come from the Sakangyi area near Mogok.

Amethyst and rose-quartz.

Small amethysts, usually of uneven colour, are obtained at many places from Deccan trap geodes, *e.g.*, in the bed of the Narbada near Jubbulpore, and used for jewellery and beads. Amethyst is common in the Sutlej valley in Bashahr, Punjab.[1] Rose-quartz is found in the Chhindwara district, at Warangal in Hyderabad and in other places[2]; it is used in cheap jewellery.

Apatite.

Green apatite derived from pegmatites in Ajmer in Rajputana is reported to have been sometimes cut into gem-stones, but this is probably beryl and a considerable quantity of apatite of a rich sea-green colour has been found at Devada, Vizagapatam district, Madras, derived probably from a pegmatite variety of kodurite.[3] Crystals of a beautiful blue colour are occasionally found in the gravels of the Mogok ruby mines.

[1] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 102, (1904).
[2] L. L. Fermor, *op. cit.*, XXXVII, p. 212, (1909).
[3] *Loc. cit.*, p. 206, (1909).

Beryl.

Beryl in its pale-coloured varieties is of common occurrence in the granite-pegmatites of India, but the crystals are generally too much fissured for use as gem-stones. Occasionally, in the pegmatite veins that are worked for mica in Bihar and in Nellore, large crystals of beryl, many inches across, are found to include clear fragments which might be cut as aquamarines; but the only places in India where attempts have been made to excavate pegmatite solely for its aquamarines are at Padyur (Pattalai) near Kangayam, Coimbatore district, where they accompany the mineral clevelandite, at different places in the Toda hills in Rajputana, and in the Skardu *tehsil* of Kashmir. Stones of considerable value were obtained from the mine which was worked at Padyur in the early part of the nineteenth century; a pit some 30-40 feet in depth is still in existence, but no one seems to have taken an interest in the place since Mr. J. M. Heath held a lease in 1818. The whole area is impregnated with igneous intrusions and deserves more attention than it has so far received.

An output of 40 cwts. of beryl was reported from Jaipur State, Rajputana, in 1929, and in the following year 20 cwts., but no value was recorded and no further production has been reported during the period under review. In the Ajmer-Merwara district, Rajputana, 281 tons of beryl were produced in 1932, and 324 tons, in 1933. This was used for the extraction of beryllium metal, and not as a gem-stone (*see* page 428). At Sagar near Sarwar in the Kishengarh State, Rajputana, aquamarines occur in mica-bearing pegmatites.

The occurrences in Kashmir have proved to be of considerable importance and a paper by Messrs. C. S. Middlemiss and Lala Joti Parshad has already appeared in the Records of this Department.[1] The principal source of the stones is the immediate neighbourhood of Daso village, but evidence has been obtained to show that beryls and aquamarines occur further away up the Braldu and Basha valleys and also in the Rondu neighbourhood. The gems are found in veins of coarse pegmatite traversing foliated biotite-gneiss. They do not, as a rule, shew great depth of colour, but the tint is delicate and limpid. In 1915, 3·75 cwts. of beryl of varying quality were obtained in Skardu; the total value is not known but Calcutta and Lucknow jewellers offered from one to four annas a *rati* for

[1] *Rec. Geol. Surv. Ind.*, XLIX, pp. 161-172, (1919).

clear transparent crystals. In 1916 the supply increased to 4·13 cwts. In the dull state of the market for precious and semi-precious stones it was impossible to form any precise idea of the value of this yield, but it was said to be several thousands of rupees; transparent varieties fetched from 2½ to 4 annas a *rati*. In 1917, a test experiment with 20 workmen during 10 days yielded :—A-1 quality, 7,888 carats; 1st quality, small, 7,540 carats; and 2nd quality, large, 10,440 carats; the total value being close on £300. The deposits have as yet been only superficially opened up, and a long life for these mines is anticipated. The last recorded outputs are of 20 lbs. in 1920, and 55 lbs. in 1921.

A large portion of the high ground between Afghanistan (Kafiristan and Wakhan) and Chitral is composed of garnetiferous and chiastolite-bearing schists with large masses of granitic intrusions. These intrusions are variable in size and mode of occurrence, and are usually fine-grained. In one of the coarser varieties at Sirwigh-o-gaz (12,000 feet), a summer grazing ground on the road from the Lutkuh to the Arkari, beryls were observed by Mr. Tipper in 1922. A few stones of poor quality, white and badly flawed, were seen *in situ*, but in the sandy debris below the rock good hexagonal crystals were found in considerable quantities; the latter are of pleasing colour, but the majority are somewhat badly cracked and contain lines of inclusions parallel to the basal cleavage. Some of the specimens were almost of gem quality, and the locality was thought to be worth further prospecting.

Chrysoberyl.

Platy crystals of chrysoberyl have been found in the corundum-bearing felspar-veins near Kangayam in the Coimbatore district, associated with nepheline-syenites, but the crystals are too highly flawed to be suitable for gems. Yellow crystals, transparent and of good quality, are said to occur with mica and aquamarine in pegmatite veins at Govindsagar, Kishengarh State, Rajputana but this is probably yellow beryl.

Garnet.

Garnets have been worked to some extent in India from the mica-schists of Rajmahal in Jaipur State, at Shahpura in Udaipur State, in the Sarwar district of Kishengarh State, and in the district of Ajmer-Merwara, all these localities being within a relatively small distance of each other. Returns have not been available to show the condition of the industry in the Jaipur State, but the statistics obtained in the past indicated the existence of a considerable industry in the other

areas. All these mines were closed during the ten years 1924-1933. The Kishengarh garnets are stated to be the finest in India.

It is convenient to record here a deposit of massive garnet, which might be useful for abrasive purposes, noted by Dr. Heron in 1924, at Sarsiri, a village in Ajmer, 5 miles from Mangliawas railway station, and 16 miles south of Ajmer Junction. The country rock is a dense, tough, dark green, banded granulite interbanded with white crystalline limestones. The garnet is reddish brown, and forms some 15 irregular bands more than a foot in thickness with innumerable smaller lenticles and vein-like bodies. The largest band north of Sarsiri is from 6 to 12 feet wide, forms an outcrop 15 feet high in places, and can be traced running vertically along the strike for about 300 yards. This band is not solid garnet from wall to wall, but includes streaks of quartz, calcite, a green ferro-magnesian mineral and country rock; garnet, however, forms roughly four-fifths of the whole. Dozens of loose blocks, 2 or 3 feet across, of almost pure garnet, are strewn along the outcrops of the chief bands. Sarsiri is connected with Mangliawas station by a semi-metalled road over flat country, and ample labour is available from large villages near at hand.

The garnets worked in India belong to the almandite variety, and have a purple colour. Stones of large size were obtained and their cutting for the market formed an important industry in Jaipur and Delhi. Garnets of small size but rich colour are very plentiful in the sands of the Travancore coast.

Garnets are also found in other parts of India, as in the Tinnevelly district, Madras,[1] which produced about 1,000 tons of garnet sand for abrasive purposes in 1914; the workings, however, were closed down the following year, and remained so till 1927, during which some 285 tons were recovered; in 1928, 480 tons were collected; in 1932, 147 tons and in 1933, 295 tons, valued at Rs. 2,950 (£222). Jaipur State, Rajputana, produced 7·3 tons of garnet sand, valued at Rs. 175 (£13) in 1930. Attention may be drawn to the fact that the manganese-garnet, spessartite, so characteristic of the gonditic rocks of the Central Provinces, is in America sometimes used as a gem. The Indian variety varies from a beautiful bright orange to red-brown, but has not yet been found sufficiently free from flaws to be of use as a gem.[2] Garnets are widely

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 234, (1906).
[2] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, p. 604, (1909).

developed in the banded gneiss, schist and granite of Chitral; many of the stones are of pleasing colour but are usually too flawed to be of value as gem-stones.

Hyalite. An output of 12·5 cwts. of hyalite, a colourless variety of opal, valued at Rs. 5,282, was reported from Katha in Burma, in 1923, but none was found during the quinquennium under review.

Iolite. Cordierite or iolite, a mineral exhibiting striking pleochroism, is found in the gem gravels of Ceylon, and cut as a gem under the name of lynx-sapphire and water-sapphire. A polished and roughly engraved piece of iolite found in some excavations at Budh Gaya, and showing strong pleochroism, deep violet to nearly colourless, has long been in the Indian Museum but no locality for the mineral was known.[1] It has now been found at two localities, namely, in complex rocks composed of sillimanite, hypersthene and biotite, in the Vizagapatam Hill-tracts,[2] and in the Kadabur *zemindary*, Trichinopoly district, Madras, where Mr. P. N. Bose reported its occurrence in abundance near Udaiyapatti and Kiranur associated with labradorite and mica-schist. There are ancient pits dug apparently for this mineral. Small pebbles of iolite are also sometimes found at Mogok.

Kyanite. Kyanite is found at many localities in the Archæan formations of India and is occasionally used as a gem-stone on account of the fine blue colour it sometimes displays.[3] An authenticated locality for gem kyanite is Narnaul, Patiala State. The jewellers at Patiala call it *bruj*, and used to say that it sold at Rs. 3 to Rs. 5 per *tola*, a rate equivalent to 10*s*. to 16*s*. 8*d*. per ounce.[4] Kyanite is also plentiful in Kanaur and Bashahr in the Punjab Himalaya[5] where it has often been mistaken for sapphire.

Rhodonite. Rhodonite, a manganese-pyroxene, is used abroad (*e.g.*, in the Urals) as a gem, and cut into all kinds of ornamental objects. It is found at many localities in India associated with manganese-ore deposits, and although none of it has yet been used for ornamental purposes, suitable

[1] V. Ball, *Proc. As. Soc. Beng.*, p. 89, (1881).
[2] T. L. Walker, *Rec. Geol. Surv. Ind.*, XXXVI, p. 13, (1908).
[3] M. Bauer and L. J. Spencer, 'Precious Stones,' p. 415, (1904).
[4] P. N. Bose, *Rec. Geol. Surv. Ind.*, XXXIII, p. 59, (1906).
[5] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 102, (1904).

material for the manufacture of small objects could be obtained at several of the mines.[1]

Tourmaline.

The beautiful red tourmaline known as 'rubellite' is worked on a small scale in the Ruby Mines tract, in Möng-Mit State and near Mainglon in the Northern Shan States of Upper Burma. The production from the Ruby Mines tract during the four years 1904 to 1907 averaged 101 lbs. valued at £750. Small outputs were recorded from Möng Mit and Mainglon up to 1909. Since then no figures have been received.

An interesting report was published in 1908, by Mr. E. C. S. George, Deputy Commissioner of the district,[2] on the workings for tourmaline round the small Palaung hamlet of Sanka about a mile east of Maingnin, where operations were carried on by the Chinese, according to local tradition, some 150 or 200 years ago. Mr. George states that after the Chinese deserted the area, the Kachins reopened the mines, but the industry was again interrupted until about 1885, when more systematic operations were commenced under Pu Seinda, who contracted to conduct all mining operations until 1895. The Möng-Mit (Momeit) Stone Tract was afterwards notified by Government and regular licenses were taken up in 1899. During the years 1903 to 1905, the amounts recovered from 'tourmaline licenses,' the rate being Rs. 2 per worker per month, were Rs. 2,000 (£133) to Rs. 3,000 (£200) each year; since then they must have fallen off.

The tourmaline is found in soft, decomposed granite-veins, which, being generally covered by a thick deposit of jungle-clad soil, are found rather by accident than through the guidance of any superficial indications. Isolated crystals are found occasionally lying in the red soil, and men with small means sometimes find it profitable, when they have leisure, to search through the soil-cap by digging shallow pits. *Twinlons* or vertical shafts, about 4 to 5 feet square, are also put down on the chance of striking a tourmaline-bearing vein, or *kyaw*, and the owners of these *twinlons* are permitted to extend their workings underground to a radius of five fathoms from the centre of each shaft. Some of the workings extend to depths of about 100 feet, which appears to be about the limit of the miners' engineering skill. The tourmaline found is sorted into three classes: (1) *ahtet yay*, the best light-pink

[1] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, pp. 144-604, (1909).
[2] *Rec. Geol. Surv. Ind.*, XXXVI, pp. 233-238, (1908).

rubellite, of which there are two kinds, *hteik ti*, showing well-developed basal planes, and *be yan*, crystals terminated by rhombohedral faces, or with only a small development of the basal plane; (2) *akka*, of a darker colour, with the lower part of the crystals brown or black in colour; (3) *sinzi* or *arnyi*, all fragmentary crystals of any colour which are imperfect, or of a small size, less than about an inch. The *sinzi* is given without charge to the buyer of the lots of the two better kinds. The best kind, *ahtet yay*, may bring as much as Rs. 1,200 to Rs. 1,500 a viss (3·65 lbs.). The *myaw* system, or exposure of the veins on the hill-side by hydraulic action, has also been attempted at two localities with uncertain results: this work is limited to the rains and is handicapped by the cost of leading the water-channels for long distances. All locally-made purchases are effected by brokers, usually Shans or Shan Burmans. They in turn sell at Mandalay to purchasers for the Chinese market.

In 1909, seven stones weighing 63·8 *ratis* or 37·5 carats,[1] valued at £26, were found in the Northern Shan States.

A beautiful green tourmaline with a crystalline limestone matrix is worked in a small way at Namon near the Salween river in the Southern Shan States. Green and blue varieties occur in the pegmatites of some parts of the mica-mining area of the Hazaribagh district, but the stones are not worth the cost of extraction.

Green tourmalines are also found at the sapphire mines area of Zanskar in Kashmir.

Zircon.

The mineral zircon is known in various parts of India, and where it occurs in the nepheline-syenite series near Kangayam in the Coimbatore district, it is picked up in small quantities and passed into the market as corundum; it is, however, nowhere found sufficiently transparent and flawless to be used as a gem. Similar material is met with in Travancore (*see* page 120). Sherry-coloured zircons are found in the Mogok Stone Tract.

Glass-making materials.

[Cyril S. Fox.]

In the pre-war quinquennial period 1909-1913, only three firms appear to have been engaged in making glassware in India. In 1921, no less than 32 firms were reported as making glass in this

[1] At 1 *rati*=1¾ grains troy=0·592 carat.

country. At the present time, largely owing to the general trade depression, the number of firms at work in the domestic glass industry is believed to be less than 16. There is no doubt that the need created by the Great War led to this rapid development in glass-making in India. Already in 1919 it was estimated that the glassware made in India was roughly one-fourth the value of the imported glassware. However, as no statistics of the domestic industry appear to be available, it is not possible to draw comparisons now. Data for imported glassware for the period 1929-1933 are given in the accompanying Tables 139 and 140.

TABLE 139.—*Value of imports of Glass and Glassware.*

——	1929	1930	1931	1932	1933
	Rs.	Rs.	Rs.	Rs.	Rs.
Bangles	88,12,817	52,46,672	40,37,843	40,05,574	28,31,809
Beads and false pearls . .	29,22,945	19,17,013	12,24,929	10,19,833	14,10,985
Bottles and phials . .	37,41,441	34,07,903	25,82,964	24,00,461	22,17,915
Funnels, globes, and glass parts of lamps	23,22,227	13,01,824	9,48,542	6,09,235	5,03,463
Scientific glassware . .	1,39,029	1,40,604	1,37,116	1,29,413	1,21,322
Sheet and plate . . .	30,14,767	25,54,040	21,57,781	20,68,140	22,89,388
Tableware (including decanters, etc.)	12,24,520	9,89,530	7,99,542	4,98,371	5,08,762
Other glassware . . .	29,70,206	23,46,798	21,05,144	27,70,348	27,22,088
Government imports . .	3,65,307	3,68,044	3,03,004	2,45,353	2,08,117
TOTAL .	2,55,12,759	1,82,72,428	1,42,46,865	1,37,46,723	1,28,08,849

TABLE 140.—*Value of imports of Glassware according to country of origin, excluding Government imports.*

—	1929	1930	1931	1932	1933
	Rs.	Rs.	Rs.	Rs.	Rs.
United Kingdom . . .	21,10,746	19,34,842	13,42,148	11,91,273	11,83,152
Germany	36,44,255	23,98,896	23,60,337	17,70,060	14,33,784
Belgium	23,33,509	18,64,848	14,96,543	13,17,223	12,63,087
Austria	4,37,308	3,33,976	1,63,523	1,18,416	1,47,625
Czechoslovakia . . .	69,28,377	41,67,624	29,42,842	22,43,511	19,50,444
Italy	5,65,175	3,42,851	2,77,935	1,98,515	2,39,640
Japan	75,88,688	55,78,809	46,39,783	60,53,983	57,78,302
Other countries . . .	15,39,394	12,82,538	7,20,750	6,08,389	6,09,748
TOTAL .	2,51,47,452	1,79,04,384	1,39,43,861	1,35,01,370	1,26,05,732

It is seen from Table 139 that the value of imported bangles and beads, *i.e.*, glassware for personal adornment, fell from Rs. 117 lakhs in 1929 to under Rs. 43 lakhs in 1933. The value of all kinds of glassware imports has fallen during the same period 1929-1933: especially is this true for the imports of glassware from Europe—Czechoslovakia, Germany, Belgium and the United Kingdom, chiefly. On the other hand, the imports from Japan have fallen to a much smaller extent. However, notwithstanding the trade depression, the lowest value for imported glassware, that of 1933, is no less than Rs. 128 lakhs. So that given suitable raw materials and efficient machines and qualified workmen there is a considerable market in India for glassware of different kinds, especially bottles and phials, sheet and plate glass, to say nothing of bangles and beads already mentioned. The technology of glass manufacture with particular reference to India has been discussed in the *Industrial Handbook, Indian Munitions Board*, p. 265, (1919), and more fully in *Bulletins of Indian Industries and Labour*, No. 29, (1922).

Raw materials.

The chief constituents in the preparation of glass are *silica*, usually in the form of quartz sand or powdered quartzite, and *alkali* or sodium oxide in the form of sodium carbonate (soda ash) or sodium sulphate (salt cake). These materials when fused together yield molten glass.

If the materials are pure, especially when free of metallic oxides, *e.g.* iron oxide, the resulting glass is clear and readily fusible and somewhat soft, *i.e.* easily scratched. By adding lime or limestone, a less fusible and harder glass is made. For specially hard or heat-resisting glassware, alumina is added to the batch. Borax is often used when a specially clear optical glass is desired, but in this case it is essential that the other raw materials should be very free of impurities. Similarly, if coloured glass is required, special colouring agents are added. Where the raw materials are not quite pure and the resulting glass has a tinge of colour, a corrective or decoloriser is used; *e.g.* manganese dioxide will correct the greenish tinge due to small amounts of iron oxide. However, the main constituents are good quartz sand, or crushed quartzite, and alkali.

It has been found that a coarse sand delays the fusion of a batch (mixture) while too fine a sand may produce dust in the furnace and cause turbidity in the glass and render the composition of the glass variable. Experience has shown that equal sized grains of quartz are most desirable and that the variations should not exceed 0·025 inches (diameter of grains) or fall below 0·005 inches. The so-to-speak 'perfect sand' is that of Fontainbleau near Paris where about 80 per cent. of the sand consists of particles between 0·009 to 0·012 inches in diameter, and averages over 99·9 per cent. silica. Among other suitable so-called 'glass sands' may be mentioned those of Lippe (99·8 per cent. silica), Aylesbury (99·5 to 99·8 per cent. silica) and Berkeley Springs (99·65 per cent. silica) in Europe and America. For ordinary window glass, the silica content need not be quite so high, while for greenish bottle glass, the purity is often appreciably less.

Sands of the degree of purity requisite for glass-making occur in several places in India. At Mangal Hat and Patraghatta, in the Rajmahal Hills, there occur white Damuda sandstones which after crushing, washing, and sieving yield sand from which glass of ordinary quality can be made. The presence of kaolin in this sand appears to be the cause of an infusible scum that forms on the top of the melt with the clear 'metal' below; this scum would debar the use of the sand in pot furnaces, but would not be so serious in a tank furnace where the scum could be skimmed off. From Loghra and Borgarh (Naini) near Allahabad, a suitable sand is obtained by crushing and grading a Vindhyan quartzite. Good

quality sands can be obtained from Tertiary sandstone at Sankheda and from the Sabarmati river sand at Pedhamli, both in Baroda State. Sands of suitable quality are also reported to occur at Jubbulpore in the Central Provinces. A grit[1] occurs a mile south of Barodhia in Bundi State, Rajputana, which crumbles into a sand on the application of slight pressure and might be utilised for the purpose of glass manufacture, whilst the Infra-Trias limestones[2] in the vicinity of Garhi Habibullah and Muzaffarabad are silicified in a peculiar way resulting in the accumulation of large masses of soft, granular, almost powdery silica that might be used for the same purpose.

Chemical analysis of some Indian Sands.[3]

——	Patraghatta.	Naini.	Sankheda.	Pedhamli.	Fontainbleau for comparison.
	Per cent.	Per cent.	Per cent	Per cent.	Per cent.
SiO_2 . .	96·00	98·95	99·39	98·10	99·80
TiO_2 . .	..	0·06	0·07	0·17	..
Al_2O_3 . .	1·15	0·39	0·11	0·84	0·13
Fe_2O_3 . .	trace	0·02	0·04	0·04	0·006
CaO . .	trace	0·11	0·15	0·15	trace
MgO . .	trace	*nil*	0·05	0·07	..
K_2O . .	2·85	0·08	*nil*	*nil*	..
Na_2O . .		0·02	*nil*	*nil*	..
Loss on ignition		0·36	0·20	0·63	0·18
	100·00	99·99	100·01	100·00	100·116
Mechanical analysis—percentage over 0·25 mm, and under 0·5 mm.	..	91·1	70·7	65·4	..

[1] *Rec. Geol. Surv. Ind.*, LIX, p. 51, (1926).
[2] *Op. cit.*, LXII, p. 66, (1929).
[3] *Bull. Ind. Industries and Labour*, No. 29, p. 12, (1922).

The sands obtainable from Loghra (Lohagara Hill) and Borgarh (Bargarh) are in actual use by glass-making firms at Bahjoi, Moradabad district; Talegaon Dabhade, Poona district; Balawali, Bijnor district; and near Allahabad. In addition, sands from Jejon Doaba (Jaijon Doaba) in the Hoshiarpur district and from Sawai Madhopur in Jaipur State are used by certain firms.

Amongst the other essential raw materials used in glass manufacture the next in importance to silica (sand) is sodium oxide either in the form of sodium carbonate (soda ash) or sodium sulphate (salt cake). The soda content in the batch mixtures in use in India is higher than the average. This high soda content will result in a glass of low melting point and thus one that is easy to work. Sodium sulphate is produced in India, as a by-product in fairly large quantities. The soda ash used by many manufacturers in India is imported by, and supplies are obtained from Imperial Chemical Industries, Ltd. Saltpetre has been collected for years in Bihar, the Punjab, and the United Provinces and exported in large quantities from India. Glass-making firms obtain supplies of this ingredient from Jalesar district, Agra, Muttra, and Lahore. Calcium oxide is usually added in the form of the carbonate, limestone. Limestone of good quality occurs in various parts of India and is obtainable almost anywhere. Katni and Dehra Dun are two localities from which supplies for glass-making are obtained.

Some batch mixtures in use in India.[1]

Material.	1	2	3	4	5	6	7	8	9
Sand . .	100	100	100	100	100	100	100	100	100
Soda . .	0	50	40	2	50	43	33	48·5	58
Lime . .	10	10	12	20	15	8	16	16	12·5
Saltpetre .	..	..	2	..	4	11·5	2	6	10·5
Cullet[2] . .	..	..	..	..	50	195	..	..	..

Minor raw materials used in the industry include boric oxide used only for very special optical glass; one per cent. of borax greatly improves the resistance of lead tableware glass to corrosion

[1] Indian Munitions Board. Industrial Handbook, p. 268, (1919).
[2] Cullet is merely another name for broken or waste glass.

by water. The borax used by Indian glass-making firms is all imported either from Europe or Tibet; it is brought down to the plains of India from Ladakh and Western Tibet. Various colouring agents are used, of which the more important are pyrolusite, an oxide of manganese, nickel oxide, selenium and salts of chromium. The first three are also used as decolorisers, the action depending on superposing one tinge of colour, due to impurities, with an equal depth of a complimentary colour. Manganese dioxide used by Indian manufacturers is largely obtained from the Central Provinces, though material of the requisite purity is also obtained in the Pani mine, Chhota Udepur State.

Impurities.

The impurities that may be harmful in glass-making are mainly those that may be present in the sand used. Alumina may be useful in glass that has to withstand pressure and heat as in thermometers, ampules, gauge glasses, combustion tubing, etc., as it reduces the coefficient of expansion and increases the hardness, brilliancy, and tenacity. Its disadvantages in glass manufacture are that (*a*) it decreases the fusibility, (*b*) when present in excess of 3 per cent. it appreciably increases the viscosity at working temperatures, (*c*) glasses with alumina do not readily mix with others so that it cannot be used for cullet, (*d*) where salt cake is used and alumina is present there is a tendency to a slightly blue colour on account of the formation of an aluminium compound similar to ultramarine. If the alumina occurs as muscovite or clay it can be removed by washing the sand, but if it occurs as felspar it cannot be so removed.

Iron compounds occur as films coating the quartz grains or in particles of ilmenite or magnetite. If no decoloriser is used 0·02 per cent. or less of ferric oxide gives a colourless glass, the colour increasing to dark green with from 1 to 1·5 per cent. If decolorisers such as manganese dioxide, nickel oxide, or selenium can be used a higher proportion of iron is permissible. Magnesia is undesirable as it makes the glass viscous and 'stringy'. Organic matter in the sand chars when the batch is heated causing black spots that are not easily burnt out.

Raw materials.

There are certain raw materials consumed in the glass-making industry that are not included in the actual composition of the glass. These include refractory materials for the furnaces and coal for firing the furnaces. The sources of these materials may be seen by reference to the

appropriate section of this review and it may be mentioned in passing that the cost of fuel constitutes one of, if not the, greatest items in the industry and hence a cheap supply of fuel is of paramount importance.

The choice of the raw materials for glass manufacture is a matter of great importance, as the quality of the finished product depends very largely on the purity of the raw materials used. Suitable materials are available in India, so far as the major ingredients are concerned, and one of the most important considerations is that of the location of the factory so that these materials may be brought together with the minimum of expenditure on transport.

The Industry.

For a long time past there has been an indigenous glass industry manufacturing inferior varieties of coloured glasses from the impure sands of certain rivers with the efflorescent alkali known as *reh*. This glass is sold in lump form and remelted by the buyers and utilised in the preparation of bangles. This is a flourishing industry at Firozabad, near Agra, where perhaps 20 works are engaged in the cutting of bangles alone. There is, however, a modern glass industry in India, dating from about 1914, and comprising works equipped with tank and pot furnaces and with glass blowing and handling appliances. There are eight such works in Bengal, seven near Calcutta and one at Dacca; two in Bihar and Orissa—at Patna and Cuttack; one in Madras at Thonderpet; four in the Central Provinces—Nagpur (two), Jabalpur and Bhandara; at least eight in the United Provinces—Firozabad (several), Allahabad and Naini, Hathras, Balawali and Bahjoi; three in the Bombay Presidency—Bombay (Mazgaon), Talegaon-Dabhade, and Ogalewadi (Satara); and nine in the Punjab—three at Panipat, two at Amritsar, one each at Ambala, Ludhiana, Qadiam and Shahbad Markanda.

The glassware made in the modern type of works is practically confined to phials, bottles, jars, lamp chimneys, shades and globes, tumblers, jugs and cheap tableware, in many cases also paper weights, and more rarely, *e.g.* at Ogalewadi, pressed ware such as plates and dishes. Sheet and window glass is made at Bahjoi only, so far as available information goes. No plate glass, glass tubing or special glassware, such as optical, heat-resisting or laboratory glassware, appears to be prepared in commercial quantities in India yet. This class of glassware—especially plate and

tubing—either requires elaborate, costly machinery or entails a degree of skill and endurance which is unattainable in a tropical climate.

In conclusion it may be said that the Indian glass industry appears to consist of independent firms each working on its own without any kind of understanding between them. There is room for co-ordination and for improvement in methods of manufacture, quality of materials and in various economies—both in a better knowledge of the available raw materials and in increasing sales by studying the markets. At present it is difficult to secure detailed statistics of production and of the quality of the raw materials, etc., utilised. Except for the alkali (soda) and certain chemicals, practically everything else for this industry, including furnace materials, is available in India.

Gypsum.

[E. R. GEE.]

Occurrence.

Gypsum occurs in considerable abundance in various parts of India, occurring both in the fibrous form and as clear selenite crystals. In Baluchistan, the Tertiary clays, and shales of all ages, whenever they are but slightly disturbed, contain numerous crystals of gypsum scattered throughout their mass[1]; in Sind it occurs in beds, sometimes three to four feet thick, near the top of the Gaj beds of the Khirthar range; in Kachh it occurs in abundance in the rocks below the Nummulitic limestones. In the Salt Range, it occurs in large masses within the Saline series which lies underneath Palæozoic beds but is, according to recent work of lower Tertiary age[2]; whilst along the foot of the Kala Chitta range in the Rawalpindi and Attock districts, it is characteristic of the Upper Nummulitic stage, reaching thicknesses of a few feet locally.[3] Massive white gypsum of good quality occurs at the top of the Saline series in the Kohat district, North-West Frontier Province, and at Kalabagh and Mari Indus in the Punjab; it is Eocene in age. Again, in the Khasor range, below Kingriali peak, massive white and grey gypsum occurs as thick beds

[1] E. Vredenburg, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 209, (1909).
[2] *Current Science*, Vol. II, No. 12, pp. 460-463, (June, 1934).
[3] E. H. Pascoe, *Mem. Geol. Surv. Ind.*, XL, Pt. 3, p. 375, (1920).

below the Talchir boulder-bed. The mineral is especially characteristic of the Lower Tertiary of north-western India, and is plentiful in the Pegu beds of Burma in the transparent form of selenite.[1]

A very interesting and, judging from the returns, comparatively important occurrence is one located eight miles N.N.W. of Nagaur in Jodhpur (Marwar), Rajputana,[2] where a bed, five feet thick or more, occurs over an area of eight square miles in silt probably formed in an old salt-lake. From 1929 to 1933, the largest production of gypsum was, as formerly, obtained from Jamsar in Bikaner, Rajputana (*see* Table 141). An analysis in the laboratory of the Geological Survey of India shewed—

	Per cent.
SiO_2	1·20
$Fe_2O_3+Al_2O_3$	0·48
CaO	32·39
MgO	0·48
SO_3	44·14
H_2O (combined)	20·16
CO_2	0·86
	99·71

The quality is, therefore, good, and large quantities are available. Lesser quantities occur in many other places in Bikaner. Selenite crystals of similar origin to the deposit of Nagaur have been recently found in the *kankar* near the base of the silt in the Sambhar lake, Rajputana. A small gypsum deposit of no economic value occurs in the Chambal valley, Dholpur State.[3]

In the Trichinopoly district of Madras, fibrous varieties of gypsum occur in clays and shales of Cretaceous age.[4]

Thick beds of gypsum are said to occur in the Kangra Chhu in Bhutan,[5] in association with dolomite. The mineral is also known in limited quantities in the Older Alluvium, in the Hamirpur district, United Provinces,[6] and under similar circumstances in the adjoining parts of the Jhansi district,[7] where it is called *usraith*. Gypsum is also found in Spiti and Kanaur, in the Punjab Himalaya. Between

[1] *Ibid.*, Pt 1, p. 216, (1912).
[2] A. M. Heron, 'The Mineral Resources of Rajputana' *Trans. Min. Geol. Inst. Ind.*, XXIX, Pt. 4, p. 355, (1935).
[3] A. M. Heron, *Rec. Geol. Surv. Ind.*, XLIV, p. 20, (1914).
[4] V. S. Swaminathan, *Trans. Min. Geol. Inst. Ind.*, XXV, Pt. 2, p. 131, (1930).
[5] G. E. Pilgrim, *Rec. Geol. Surv. Ind.*, XXXIV, p. 28, (1906).
[6] T. D. La Touche, *op. cit.*, XXXVII, pp. 281, 285, (1909).
[7] C. A. Silberrad, *op. cit.*, XLII, p. 56, (1912).

the Lipak and Yuland rivers in Kanaur the gypsum occurs in immense masses and thick beds replacing Carboniferous limestone; it is used locally for whitewash, but the inaccessibility of the deposits would render abortive any attempt to mine the mineral for transmission to the Indian markets.[1] Very minor occurrences of gypsum are reported among the Krol limestones of Sirmur State.[2]

Uses.

The chief uses of gypsum are as a fertiliser for the soil and in the manufacture of Plaster of Paris. It also has the useful property of retarding the setting of any cement of which it forms an ingredient, and from that industry a fairly steady demand is forthcoming. Its effect in small quantities upon crops is said to be remarkable, and its usefulness to the monsoon crops of south Bihar has been experimentally demonstrated.[3] A common application is two maunds to the acre. Increasing amounts of gypsum are being imported by the Department of Agriculture, Bihar and Orissa, from the Jamsar quarries in Bikaner.

Gypsum has been used in stucco work, and for the manufacture of lattices and open-work screens in various parts of India since ancient times. These, and other local industries are described in the Quinquennial Review of the Mineral Production of India, 1924-28.[4]

Production.

At the commencement of the previous quinquennium — 1924 to 1928—about two-thirds of India's total production (38,123 tons) came from Bikaner State. By the year 1928, however, both the Jhelum district, Punjab and Jodhpur State had increased their outputs considerably, the production figures of these two areas and of Bikaner being about 18,000, 15,000 and 25,600 tons respectively, out of a total production of a little over 59,000 tons.

As will be observed from Table 111, Bikaner retained the lead until 1932 when its output was exceeded by that of Jodhpur State; in 1933 Bikaner was also passed by the Jhelum district, Punjab. In the latter year, there was a marked fall in India's total production.

In the Salt Range, Punjab, the quarrying of massive gypsum at Khewra, by the Northern India Salt Revenue Department, was

[1] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 101, (1904).
[2] *Rec. Geol. Surv. Ind.*, LXVII, p. 34, (1933).
[3] D. Clouston, Review of Agricultural Operations in India, (1924-25), p. 52.
[4] *Rec. Geol. Surv. Ind.*, LXIV, pp. 402-403, (1930).

TABLE 141.—*Production of Gypsum in India during the years 1929 to 1933.*

	1929		1930		1931		1932		1933	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Kashmir State	49	*50*	84	*65*	59	*65*	86	(*b*)	7	(*b*)
Madras—										
Trichinopoly	23	*245*	42	(*a*) *546*	4	*41*	75	*820*	98	*1,446*
Punjab—										
Jhelum	16,163	*22,564*	14,567	*19,871*	16,792	*18,102*	12,726	*13,150*	9,221	*9,780*
Rajputana—										
Bikaner State	21,846	*54,389*	25,452	*51,109*	19,572	*35,029*	22,296	*28,955*	6,520	*13,832*
Jaisalmer State	145	*860*	171	*921*	205	*1,201*	235	*913*	272	*1,083*
Jodhpur State	14,500	*38,800*	10,000	*41,000*	17,000	*42,500*	16,000	*42,500*	17,000	*40,000*
United Provinces—										
Garhwal	..	..	..	..	..	..	3	*4*	14	*25*
Total	**52,726**	*1,17,702*	**56,316**	*1,13,512*	**53,632**	*97,938*	**51,421**	*86,342*	**33,142**	*66,166*
	..	*£8,784* (£1 = Rs. 13·4)	..	*£8,408* (£1 = Rs. 13·5)	..	*£7,254* (£1 = Rs. 13·5)	..	*£6,491* (£1 = Rs. 13·3)	..	*£4,975* (£1 = Rs. 13·3)

(*a*) Estimated. (*b*) Not reported.

commenced in 1927-28 and, during the final year of that quinquennium, the production amounted to 7,426 tons. During the first four years of the quinquennium under review, the production of this subsidiary industry slumped from 6,693 tons valued at Rs. 14,268 during 1929-30, to 2,167 tons 12 cwts. in 1932-33. This was partly due to competition by private traders at Dandot, 3 miles west of Khewra and to the general depression in trade. During the financial year 1933-34, there was a recovery in the Khewra production to 5,463 tons.

During the quinquennium 1929 to 1933, the recorded value of Jodhpur gypsum remained fairly steady at about Rs. 2·6 per ton. That of Bikaner dropped from about Rs. 2·5 in 1929 to Rs. 1·3 in 1932, but rose again in the following year to about Rs. 2·0. Gypsum from the Jhelum district fell in value from nearly Rs. 1·5 in 1929 to a little over Re. 1·0 in 1933.

The largest producer of gypsum in the world is the United States of America, and the bulk of their output is used for the manufacture of fire-proof wall-boards. These have increased at the expense of the fibre-board on account of the ease with which they can be applied and by reason of economies effected by their use. The wall-board also lends itself to an attractive plastic finishing, which has added to its popularity. The resources of gypsum in India are large, and an increase in its use and demand would stimulate an industry capable of considerable expansion.

Kyanite (see also Sillimanite).

[A. M. Heron.]

Of recent years the minerals kyanite and sillimanite have come into prominence because of their value for certain purposes in the ceramic industries. Their uses and properties will be found described under 'sillimanite.'

The known deposits of massive kyanite in India are confined almost entirely to Bihar and Orissa. In 1907, Mr. Srinivasa Rao submitted some specimens from Lapsa Buru in Kharsawan State, Singhbhum district, Bihar and Orissa, to Sir L. L. Fermor of the Geological Survey of India. They were then thought to be composed of corundum with some tremolite. In 1908, Sir L.L. Fermor visited the hill and found considerable outcrops of kyanite-rock. Mr. K. A. K. Hallowes, in unpublished departmental reports of 1907 and 1908,

mentioned the occurrence of kyanite-bearing rocks in other parts of Singhbhum. During an examination of apatite deposits in the Mushabani-Badia tract, Dhalbhum, Sir L. L. Fermor noticed adjacent outcrops of kyanite-quartz-rock in 1918. As massive kyanite was not then of economic value, these discoveries were not made public.

The first published note on the occurrence of kyanite in Singhbhum was in the Quinquennial Review of the Mineral Production of India, 1919-23. In 1922, the material was brought to the notice of Mr. P. Bosworth Smith, who furnished information later to the office of the Geological Survey. During the field season 1923-24, Dr. Dunn was in Kharsawan State continuing the larger survey of Singhbhum. The kyanite-rock was seen at the time and briefly described.[1] During the latter part of 1926 and early 1927, Dr. Dunn took up the examination of sillimanite and kyanite deposits in north-eastern India, and made a more thorough examination of the Singhbhum deposits.

In Singhbhum, kyanite-rock, associated with kyanite-quartz-rock occurs at intervals along a belt of country nearly 70 miles in length, striking east from Lapsa Buru through the Indian States of Kharsawan and Seraikela, and turning south-east through Dhalbhum almost up to the Mayurbhanj border. The deposits strike parallel with the Singhbhum copper belt, occurring on the north and east (or hanging wall side) of the copper lodes. The main rock of this belt is aluminous muscovite-schist, but hornblende-schist frequently crops out. The mica-schist often contains large crystals of staurolite and garnet. The massive kyanite is usually associated with kyanite-quartz-rock or granulite.

At Lapsa Buru, the kyanite-quartz-rock is found in enormous beds, the massive kyanite apparently occurring as segregations in the more acid rock. Some large deposits are, however, entirely of kyanite-rock. The pure kyanite-rock is massive, never cleaved; it is usually medium to coarse-grained, and even those rocks which, in the hand specimen, appear to be fine-grained, are found to consist under the microscope of quite coarse crystals full of fine inclusions. Kyanite is almost the sole constituent. It is often of the radiating columnar variety, and blades of crystals over 12 inches long may be seen sometimes in the large boulders. Such coarse kyanite indicates the action of at least a certain amount of metamorphic migration. Usually the only other constituent is rutile, which is often plentiful; fine corundum is present occasionally.

[1] J. A. Dunn, *Mem. Geol. Surv. Ind.*, LIV, p. 166, (1929).

Other places at which massive kyanite occurs in workable amounts in Singhbhum are Ghagidih, Rakha Mines, Badia-Bakra and Kanyaluka. The minimum quantities of these present, calculated to a depth of 1 yard, are :—

	Tons.
Lapsa Buru	214,000
Ghagidih	20,000
Badia-Bakra	10,000
Kanyaluka	8,000

Analyses of typical specimens of these rocks are :—

	Lapsa Buru. Per cent.	Ghagidih Per cent.
SiO_2 .	30·20	36·0
Al_2O_3 .	65·35	60·7
Fe_2O_3 .	3·19	2·3
TiO_2 .	0·06	1·2
CaO .	trace	0·8
MgO .	1·37	0·4
H_2O .	0·61	0·9
	100·78	102·3

A certain amount of massive kyanite associated with blue corundum has been found at Rengadih in Manbhum, but it is of poor quality.

TABLE 142.—*Production of Kyanite during the years 1929 to 1933.*

—	1929		1930		1931		1932		1933	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
***Bihar and Orissa*—**										
Kharsawan State	3,518	*22,577*	8,641	*1,31,505*	3,162	*45,223*	5,043	*83,172*	4,266	*68,888*
Singhbhum .	100	*1,500*	..	..	247	*3,705*	537	*8,055*	..	..
***Mysore State*—**										
Tumkur . .	..	..	..	..	..	..	..	..	17	*544*
***Rajputana*—**										
Ajmer-Merwara .	..	..	..	..	3	..	..	..	..	..
Total .	**3,618**	*24,077*	**8,641**	*1,31,505*	**3,412**	*48,928*	**5,580**	*91,227*	**4,283**	*69,432*

Marble.

[M. S. Krishnan.]

India has long been famous for its marbles, chiefly on account of the fine buildings such as the Taj Mahal, built from this material.

Occurrence.

The marble quarries of Rajputana seem to be of great antiquity from the fact that blocks of marble evidently from that region have been found among the remains in the excavations at Mohenjo-Daro in Sind. The best known occurrences of white marble are at Makrana in Jodhpur, Kharwa in Ajmer, Maundla in Jaipur, Dadikar and Jhiri in Alwar, and Tonkra in Kishengarh, the last-named being dolomitic marble. White dolomitic marble is also found in the Raialo series in several places in Mewar, particularly at Rajnagar to the north of Udaipur city. The Rajnagar dolomite marble is mainly white and quite as beautiful as the Makrana stone. Saccharoidal dolomite occurs in large quantities in the far-famed Marble Rocks, forming a beautiful gorge traversed by the Narbada river near Jubbulpore. Fine snow-white marble, suitable for statuary and for ornamental building purposes, occurs in the valley of the Duddur, three miles south of Buta Kundi in the Hazara district, where it forms a bed some 600 feet thick and is exposed in precipitous wall-like cliffs. Large lenticular masses also occur in the Salkhala series of Kaghan in the Hazara district and in the adjoining parts of the Muzaffarabad district. The Betul district of the Central Provinces has in the past yielded good white marbles. Almost unlimited quantities of similar white marble are found in the hills of Kyaukse, Sagyin and Mandalay, on the banks of the Irrawaddy, while the Mogok Stone Tract has also large deposits. Fine white marble, partly of statuary quality, is known to occur in the vicinity of Swabi in the North-West Frontier Province, and in the Khyber tribal territory.

Homogeneous yellow marble as well as yellow and grey and cherry-red and yellow shell marble are found near Jaisalmer in Rajputana. A chocolate and grey limestone occurs in Kotah State. Pink marbles occur in Rajputana, as at Tonkra and Narwar in Kishengarh, Makrana in Jodhpur, Ratangarh near Kharwa, and other places in Mewar. Similar pink stones are also found in the Narsinghpur district of the Central Provinces, and in great abundance in the Sausar *tahsil*, Chhindwara district. Serpentinous

limestones, showing green and yellow tints, are found in Ajmer, but the most striking example of this class occurs at Motipura in the Baroda State in the form of a handsome mottled green marble. A brecciated marble is obtained at Sandara in Baroda, while a light green marble is worked in Kharwa State. A black marble, taking a good polish, and also other varieties, are found in Rajpipla State. Fine black, or banded dark grey, marbles occur at Baislana, Jaipur State. Mottled and grey-streaked marbles occur in Jodhpur. White dolomitic or yellowish serpentinous marbles occur in great abundance in the Nagpur and Chhindwara districts of the Central Provinces and in Idar State. Mottled pale green and yellow varieties are found near Swabi in the North-West Frontier Province.

The Archaean crystallines of the southern and south-eastern parts of the Peninsula also contain marbles in several places. A pale grey variety occurs in the Gangpur State, Orissa. White, green and grey marbles are found in the Vizagapatam hill tracts, while grey, pink and black varieties occur in the Trichinopoly, Coimbatore, Madura and Tinnevelly districts. White, grey and greenish varieties have been noted near Sua and other places in Palamau, Bihar.

A fine coralline limestone, capable of a high polish, is quarried in the Indore State and used in the construction of temples and palaces. Variegated serpentinous limestones occur in parts of the Cuddapah and Karnul formations of the Madras Presidency. A mottled concretionary dolomitic marble occurs in the Vindhyan series in the Gwalior State, whilst onyx marbles are found at Nurpur in the Shahpur district, and near Jhuli in the Baluchistan desert.

An excellent resumé of the marble resources of Rajputana will be found in a recent paper by Dr. A. M. Heron[1].

Victoria Memorial.

Extensive tests made by Sir L. L. Fermor in the laboratory of the Geological Survey of India on the Makrana marble[2] shewed that it is superior in many respects to the marbles imported from Greece and Italy, and it was therefore employed in the construction of the Victoria Memorial in Calcutta. Messrs. Martin & Company operated some quarries at Makrana for this purpose.

[1] *Trans. Min. Geol. Inst. Ind.*, Vol. XXIX, pp. 311-327. (1935).

[2] T. H. Holland, *Journ. Queen Victoria Indian Memorial Fund*, No. II, March, 1904, pp. 18-26; T. H. Holland and L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIX, pp. 260-263, (1910).

TABLE 143.—*Production of Marble in India during the years 1929 to 1933.*

—	1929		1930		1931		1932		1933	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Rajputana—										
Alwar	..	..	..	..	..	..	..	..	10	*450*
Jaisalmer	500	*7,525*	181	*2,700*	112	*1,530*	104	*1,185*	138	*1,259*
Jodhpur	5,300	*2,12,000*	4,300	*1,62,000*	3,963	*1,42,500*	4,860	*1,75,000*	4,604	*1,60,000*
Total	**5,800**	*2,19,525*	**4,481**	*1,64,700*	**4,075**	*1,44,030*	**4,964**	*1,76,185*	**4,752**	*1,61,709*
Total value in sterling	..	*£16,382* (£1 = Rs. 13·4)	..	*£12,200* (£1 = Rs. 13·5)	..	*£10,669* (£1 = Rs. 13·5)	..	*£13,247* (£1 = Rs. 13·3)	..	*£12,158* (£1 = Rs. 13·3)

Production.

The average annual output from Makrana for the past three quinquennial periods was: 1914-1918—3,500 tons; 1919-1923—6,650 tons; 1924-1928—4,350 tons. During the five-year period under review the annual output averaged 4,605 tons. Table 143 shows the total production of marble in India from 1929 to 1933

Imports and exports.

In spite, however, of the existence of large supplies of marbles of every variety in different parts of the Indian Empire, there is a large import trade in marble from abroad, chiefly from Italy and Greece. This is due partly to the great distances that separate the Indian marble deposits from such large centres as Calcutta and Bombay, and partly to the systematic organisation and mechanical efficiency of the quarrying operations in Europe, because of which foreign marble can be produced cheaply. The import into and export from India of 'stone and marble' for the period under review is shown in Table 144. On account of the freight advantages attaching to the supply of foreign marbles, it would probably not pay to lay out much capital on Indian marble quarries; but, with an order sufficiently large to warrant systematic quarrying operations, marble ought to be procurable at a cost that would repay its employment locally in Rajputana. the Central Provinces, and possibly in Burma. Some of the marble deposits in Burma have an advantage in that they are situated on the banks of the Irrawaddy, and therefore well suited for water transport.

TABLE 144.—*Imports and exports of stone and marble.*

Year.	IMPORTS.		EXPORTS.	
	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*
1929	6,106	*4,90,767*	2,712	*1,91,092*
1930	5,206	*5,17,232*	2,718	*1,16,585*
1931	4,992	*4,63,160*	4,491	*1,03,640*
1932	5,745	*4,87,522*	3,085	*79,341*
1933	8,966	*5,64,721*	11,433	*3,43,786*
Total .	**31,015**	25,23,402	*24,439*	842.444
Average 1929-33 .	*6,203*	*5,04,680*	*4,888*	*1,68,489*
Average 1924-28 .	*6,090*	*7,58,045*	*3,332*	*60,999*

Mineral Paints.

[M. S. KRISHNAN.]

Under this heading only the naturally coloured mineral pigments used in the paint industry are included. The ochres usually consist of a clay base thoroughly permeated by a colouring matter which is generally ferric oxide. Red ochre and red oxide contain a high proportion of ferric oxide and show a wide range of colours from red through brown to nearly black. When ground, however, the powders show a shade of red colour, but the harder varieties are scarcely worth grinding, because of the expense. The brown earth colours are called umber and sienna, the colour in these being attributable to the presence of manganese oxide.

They are used for a variety of purposes—for the manufacture of paints (mixed with oils), and for staining cement, linoleum, rubber, wall paper, wood, etc.

A summary of the distribution of mineral colours in India will be found in an article entitled 'Barytes and Mineral Colours' by Dr. J. Coggin Brown[1], and in the Annotated Index to Minerals of Economic Value by Mr. T. D. LaTouche[2]. To the information contained in these two publications are added a few times which have come to the notice of this department in the last few years.

Red and yellow ochres of good quality are found as pockets in the Dharwarian phyllites in the neighbourhood of Goilkera in the Singhbhum district. Red ochery shale of liver-brown to chocolate colours occurs as thin lenses in the Himgir sandstone of the Himgir *zamindari*, Gangpur State, Bihar and Orissa. In the coal beds exposed in the Baisundar river north of Gopalpur (22° 3′ : 83° 42′) in the same State, there is a band of fine red ochre (better classified as red oxide) partly mixed with granular vitrain. This band is from nine to twelve inches thick and has been estimated to contain about 14,000 tons within a shallow depth.[3] A sample analysed in the Geological Survey laboratory gave :—

	Per cent.
[illegible]	[illegible]
Alumina	1·52
Ferric oxide	87·72
Lime and magnesia	trace
Moisture	3·90
Loss on ignition	5·46

[1] *Bull. Indian Industries & Labour*, No. 22, (1921).

[2] Bibliography of Indian Geology and Physical Geography, Part II, pp. 392-396, (1918).

[3] *Rec. Geol. Surv. Ind.*, LXVII, p. 37, (1933).

TABLE 145.—*Production of Ochre in India during the years 1929 to 1933.*

	1929		1930		1931		1932		1933		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Central India	4,954	*35,793*	4,499	*36,522*	364	*3,360*	1,857	*15,274*	5,315	*42,082*	3,498	*26,606*
Central Provinces	2,755	*12,757*	1,954	*7,389*	2,328	*11,693*	3,365	*9,747*	5,118	*11,334*	3,204	*10,584*
Gwalior	521	*6,125*	451	*4,263*	567	*5,656*	403	*3,277*	382	*2,077*	465	*4,280*
Madras	325	*4,500*	375	*4,050*	300	*3,550*	300	*3,550*	363	*3,126*	332	*3,755*
Rajputana	377	*1,714*	332	*1,121*	312	*1,076*	312	*1,262*	318	*1,316*	330	*1,297*
United Provinces	..	..	..	..	80	*560*	..	..	134	*960*	43	*304*
Total	**8,932**	*60,889*	**7,611**	*53,345*	**4,951**	*25,895*	**6,237**	*33,110*	**11,630**	*60,895*	**7,872**	***46,826***
Total value in sterling	..	**£4,540 (£1 = Rs. 13·4)**	..	**£3,951 (£1 = Rs. 13·5)**	..	**£1,918 (£1 = Rs. 13·5)**	..	**£2,459 (£1 = Rs. 13·3)**	..	**£4,578 (£1 = Rs. 13·3)**	..	**£3,495**

This material is soft and easily powdered and possesses a pleasing colour equal to some of the best imported red ochres.

Yellow ochre occurs in the Madavaram reserved forest area in the Kurnool district of Madras. There was a small production from here during the period under review. A grey to bluish grey clay called 'grey ochre' is available in large quantities on the slopes of the Nallakonda (14° 27′ : 78° 57′) in the Cumbum slates of the Cuddapah system. It is learnt that a private concern has recently applied for a lease of this deposit from the Madras Government.

Green earth found in the Deccan traps and in certain inter-trappean horizons, is known to occur near Wagora, Central Provinces, in the Bhilsa district of Gwalior, in the neighbourhood of Bhopal, and in the Dharampur State, Surat. No information is available whether any of this material was produced on a commercial scale.

A black slate from near Kishengarh has been successfully used by the Rajputana-Malwa Railway as a paint material. Similar black, carbonaceous and graphitic rocks occur in the Dharwarian rocks of Chota Nagpur and Central Provinces and in some of the formations in the Simla Himalayas and in the Kashmir-Hazara area, but none of these has yet been tried on a commercial scale.

In Table 145 are given the figures of production of ochres in India, as far as information is available. These represent only the material worked under lease, commercially prepared and marketed. In addition, large quantities of coloured earths are won throughout the country for purely local consumption for such requirements as colour-washing of houses. Though the aggregate quantity must be large, not even a rough estimate of this is available.

Since the war, several paint manufacturing concerns have sprung up in this country which have successfully put their products on the

TABLE 146.—*Imports of paint materials into India.*

—		1929	1930	1931	1932	1933
† Coloured and white paints.	cwt.	298,224	213,026	160,239	158,540	156,504
	Rs.	72,67,620	56,23,762	41,56,356	40,19,788	41,11,685
* Total of all paints and colours.	cwt.	491,060	459,583	381,887	341,262	370,001
	Rs.	1,14,96,756	93,27,323	71,15,606	68,98,567	71,56,800
** Total of all paints and painter's materials.	Rs.	1,46,34,918	1,21,71,679	93,87,153	91,19,142	92,90,064

† Paints excluding barytes, graphite, red and white lead and zinc white.

* Includes barytes, graphite, red and white lead, and zinc white (both dry and mixed).

** Includes, in addition to the above, turpentines, varnishes, enamels and other painter's materials, but not linseed oil.

market. There is still a great scope for improvement and expansion of the local industry, as the figures of imports of paint materials given in Table 146 will show.

Mineral Waters.

[M. S. KRISHNAN.]

Mineral waters do not have the same vogue in India as in many other countries, where table or medicinal waters 'bottled at the source' find a ready sale. Many of the springs in India are resorts of pilgrimage for countless worshippers, though their waters have no sale.

India possesses a great abundance of mineral springs, many of them hot. T. and R. D. Oldham[1] have compiled a *Catalogue of the Hot Springs of India,* showing 301 of them. A list of the springs reputed to possess some medicinal value or charged with mineral matter has been prepared by T. H. D. La Touche[2] under the heading 'mineral waters'.

The results of the observations of the Rev. A. Steichen and the Rev. H. Sierp of St. Xavier's College, Bombay, on the radio-activity of the thermal springs of the Bombay and Madras Presidencies have been published in two papers in the *Indian Medical Gazette* (Vols. XLVI, (December 1911), and XLVII, (December 1912)). The springs at Tuwa on the line from Cambay to Godhra (Panch Mahals) were found to possess unusually high radio-activity. Comparatively large emanations were found at Vajrabai and Unei. Sierp has also published data for springs in the Thana district of Bombay (*Loc. cit.*, Vol. XLVIII, p. 259, (1913)).

Messrs. Kemp and Co. of Bombay sell the bottled waters of the springs at Sipry in Gwalior, as medicinal water. The following analysis has been kindly furnished by them :—

Substance.	Grains per gallon.
Calcium carbonate	7·53
Magnesium carbonate	1·09
Sodium carbonate	7·77
Sodium nitrate	0·245
Sodium sulphate	0·199
Sodium chloride	1·49
Silica	0·56
Undetermined solids	0·016
Total solids by evaporation	18·90

[1] *Mem. Geol. Surv. Ind.*, XIX, Pt. 2, (1883).
[2] *Annotated Index of Minerals of Economic Value*, Calcutta, (1918).

Sir. L. L. Fermor, in his 'Mineral Resources of Bihar and Orissa' (*Rec. Geol. Surv. Ind.*, LIII, p. 290, (1921)) has discussed the geological mode of occurrence of the springs of that Province as a guide to geological enquiry and to those who may wish to turn some of them to commercial account.

Phosphates.

[M. S. KRISHNAN.]

The mineral apatite is known to occur in many places in India. The best known deposit is found in the Dhalbhum Estate of the Singhbhum district, Bihar and Orissa, where an apatite-magnetite-chlorite rock forms a series of lenses in Dharwar schists, parallel to their strike. The lenses are of all sizes, ranging from granules and fine lenticles to those which are 200 feet long and 40 feet wide. They are generally arranged *en echelon*. Deposits have been located along a belt stretching for about 12 miles in a N.W.—S.E. direction from Patharghara to Khejurdari.[1] This belt is parallel and close to the Subarnarekha river and the Bengal Nagpur Railway, of which the nearest station is Ghatsila. A concession to work the apatite at Sungi, Kanyaluka and Badia in this belt was granted in the first place to the Great Indian Phosphates Co. Ltd., during the war. This company subsequently went into liquidation and the area was transferred to a private syndicate. In this concession an ore reserve of between 100,000 and 200,000 tons has been estimated. The ore averages about 20-25 per cent. P_2O_5, with magnetite as the main gangue mineral, but magnetic separation can raise the percentage to 35. Phosphatic rock despatched from Sungi amounted to 3,406 tons in 1923-24, and 2,273 tons in 1924-25. Reserves of at least 250,000 tons of available phosphate ore are claimed to exist in this neighbourhood.

Singhbhum, Bihar and Orissa.

About 21 miles north-west of Patharghara, and evidently forming a continuation of that belt, is another locality at Nandup some two and a half miles south of Tatanagar railway station. Here the iron content is lower and quartz is often associated with the apatite. Around Chandar Buru several parallel zones occur. During 1924-28, this area supplied 7,100 tons of phosphate for agricultural purposes and 7,600 tons to the iron trades. Of the two types of

[1] *Rec. Geol. Surv. Ind.*, L, p. 14, (1919).

deposit found in this area, one has a gangue of iron-ore and schists and the other a gangue of quartz and schist. The average grade of the former is about 17 per cent. and of the latter 22 per cent. P_2O_5 but both show improvement with depth. Since the associated iron-ore is haematite, improvement of grade through magnetic separation is limited. In this area the reserves of phosphatic ore, averaging between 20 and 25 per cent. P_2O_5 are at least 25,000 tons. This is a minimum figure as the deposits have not yet been completely opened up. From the whole of the Naudup area an average of 1,722 tons was produced annually during 1924-28.

There are also other deposits in the neighbourhood which could be utilised if the demand increased. The better quality ore might be mixed with Tata's Bessemer slag (containing 3 per cent. P_2O_5) to give a suitable product for agricultural purposes.

Trichinopoly, Madras.

In the Upper Cretaceous beds occurring in the Perambalur *taluk* of the Trichinopoly district, Madras, there is a horizon which contains phosphatic nodules of irregular shape. This bed, which is exposed in the low ridge east of Valudayur (11° 58′ 30″ : 79° 46′), extends for a distance of at least 10 miles, with an average dip of 12°, and was estimated to contain about 8,000,000 tons of nodules within a depth of 200 feet. The nodules are distributed irregularly, varying in quantity between 27 and 47 lbs. per 100 cubic feet in excavations, and 70 lbs. per 100 cubic feet in shallow workings. The nodules contain 56—59 per cent. calcium phosphate, 16—20 per cent. calcium carbonate and up to 14 per cent. silica, alumina and iron oxide. Attempts were made to utilise the powdered nodules as a fertiliser in the coffee plantations in South India and in Ceylon, but these were unsuccessful.[1] Next to the Singhbhum deposits, these should be considered as an important source of phosphates in India, but the high calcium carbonate content is a drawback in utilising these for the manufacture of superphosphate.

Mica mines, Hazaribagh and Nellore.

Apatite is an abundant constituent of the mica-bearing pegmatites of the Hazaribagh district of Bihar and Orissa, and of the Nellore district of Madras. Sometimes even the surrounding schists contain appreciable quantities of disseminated apatite. Sir Thomas Holland[2] has shown that the waste heaps in the mica mines area

[1] *Op. cit.*, XXXIX, p. 267, (1910).
[2] *Mem. Geol. Surv. Ind.*, XXXIV, pp. 50-51, (1901).

contain enough apatite to warrant economic recovery by washing and picking.

Mica-peridotite, Bihar coalfields.

The mica-peridotite dykes in the Giridih and Raniganj coalfields contain apatite as an essential constituent. The calcium phosphate content of several specimens, which have been analysed in the Geological Survey laboratory, ranges between 4·5 and 12·5 per cent. of the rock. The quantity is too small to warrant raising for economic purposes, the material comparing unfavourably with the basic Bessemer slags, but, as Sir Thomas Holland remarks, 'the decomposition of large quantities of this rock at the surface must contribute sensibly to the fertility of the neighbouring soil.'[1]

Rewa Kantha.

At Jothvad in Narukot State of the Rewa Kantha Agency, Bombay, are manganese-bearing rocks which are of no value as manganese-ores, but which contain in some cases 25 to 30 per cent. of apatite in the rock.[2] It is perhaps worth considering whether the crushed rock could be used for fertilising purposes.

Vizagapatam, Madras.

In the Vizagapatam district of Madras, apatite is a universal constituent of the rocks of the kodurite series of manganese-bearing rocks, and may often be extracted in quantity from the lithomarge resulting from the decomposition of these rocks. It is abundant at the manganese mines of Garbham (18° 22′: 83° 31′), Ramabhadrapuram (18° 30′: 83° 20′ 30″) and Devada (18° 15′: 83° 38′). Some hundredweights of deep sea-green apatite in rough prisms up to 5 inches in diameter were obtained at Devada.[3]

Vizianagram, Madras.

A lenticular patch containing apatite rock has been recorded as occurring on a hill near the village of Sitaramapuram, about 25 miles north-west of Vizianagram, and close to the road connecting the above town with Anantagiri. The country rock here is also traversed by veins rich in apatite which are up to a yard in width. In the lenticular patch mentioned above, a quantity of 5,000 tons of apatite has been estimated to occur within a depth of 30 feet. A sample from this place showed, on analysis, 40·5 per cent. phosphoric acid, 53·76 per cent. lime, 1·52 per cent. silica, 3·47 per cent. flourine, 0·55 per

[1] *Rec. Geol. Surv. Ind.*, XXVII, p. 135, (1894).
[2] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, pp. 646-648, (1909).
[3] *Ibid.*, p. 251.

cent. chlorine, and 0·22 per cent. water. The material has been reported on as being very suitable for the manufacture of superphosphate.

In the Dandot colliery (32° 39′ 30″ : 73° 1′), Jhelum district, Punjab, the shales overlying the coal seam were found to contain phosphatic nodules. The nodules contain about 65 per cent. of calcium phosphate, but their quantity was not considered sufficient for practical utilisation.

Jhelum, Punjab.

Apatite schists are reported to occur in the Dungarpur State of Rajputana, but the quantity available is not known.

Nodules of calcium phosphate and layers of phosphate rock occur in a shale band at the base of the chert beds immediately overlying the limestone at Mussoorie (30° 27′ : 78° 8′), United Provinces. The nodules contain about 76 per cent. of calcium phosphate, and the phosphatic rock about 66 per cent. Both vary considerably in composition. Exposures of the deposits were found at three places in a length of a mile.[1]

Mussoorie, U. P.

A blue earth containing the ortho-phosphate of iron, vivianite, was discovered on the banks of the Dikhu river, above the town of Nazira (26° 55′ : 94° 48′) in the Sibsagar district of Assam. The source of the phosphate, which must have been derived from further up the valley, has not been ascertained. Blue-grey clay containing abundant specks of vivianite has been recorded by Medlicott in his journey up to Khatmandu in 1874. This clay is used as a fertiliser in the Nepal valley, but further details are not available.

Assam and Nepal.

Masses of triplite occur in a mica mine two miles south-east of Singar (24° 34′ 30″ : 85° 33′ 30″) in the Gaya district. The mineral contains about 32 per cent. of phosphoric acid. The deposit was considered to be probably of small value as a source of phosphoric acid, but an output of 10 tons of the mineral was recorded in the year 1914.

Gaya, Bihar.

Large quantities of bones and bone meal are still being exported from India, though bone meal and other animal manures are now being manufactured in India. The want of a cheap supply of sulphuric acid, has, in the past, prevented the manufacture of superphosphates. Sulphuric acid is now being produced on an appreciable scale in this country

Bones and bone meal.

[1] W. King, *Rec. Geol. Surv. Ind.*, XVII, pp. 198-199, (1884); F. R. Mallet, *op. cit.*, XVIII, p. 126, (1885).

and a start has been made in the manufacture of superphosphate by Messrs. Parry & Co. at Ranipet near Madras.

The Institute of Agricultural Research at Pusa has demonstrated the value of utilising the Bihar apatite in the manufacture of lime phosphate[1]. A recent paper by S. Das gives the details of an electrolytic method of production of di-calcium phosphate from Bihar apatite, and this process is claimed to be economically feasible[2].

Exports and imports.

In Tables 148 and 149 are given the exports and imports of manures from and into India respectively.

Basic slag.

Basic slag formed in the manufacture of steel usually contains phosphates in sufficient quantity to make the ground material valuable as a fertiliser. Indian basic slag is said to be rather poor in phosphates, so that it is not likely to be useful as fertiliser. The only company manufacturing steel on a large scale in India is the Tata Iron and Steel Company at Jamshedpur. The basic slag averages about 250-300 lbs. per ton of steel produced, the P_2O_5 content being around 2·8 to 3·2 per cent. of the slag. During the quinquennium under review, the basic slag produced by the above Company amounted roughly to 49,625 tons in 1929; 38,875 tons in 1930; 31,575 tons in 1931 24,000 tons in 1932 and 24,750 tons in 1933. This is all dumped near the works as there is no demand.

TABLE 147.—*Production of Phosphate rock in India.*

		1929	1930	1931	1932	1933
Bihar and Orissa.						
Singhbhum	Tons	*Nil*	220	*Nil*	*Nil*	*Nil*
	Rs.	..	3,300	..	..	..
	£	..	244	..	..	..
Madras.						
Trichinopoly	Tons	22	31	109	121	37
	Rs.	202	294	1,067	1,071	372
	£	15	22	79	81	28

[1] D. Clouston. Review of agricultural operations in India, (1921-25), p. 55.

[2] Electrolytic production of dicalcium phosphate from apatite in India. *Journ. Soc. Chem. Industry*, XLIX, pp. 490T—492T, (1931).

TABLE 148.—*Exports of Manures from India during 1929 to 1933.*

	1929	1930	1931	1932	1933
	Tons.	Tons.	Tons.	Tons.	Tons.
Bones for manurial purpose	66	76	3,202	3,575	3,678
Bone meal	41,272	34,168	34,739	24,710	17,918
Total of bones	41,338	34,244	37,941	28,285	21,596
Fish manures and guano	9,059	4,660	5,516	4,642	4,636
Sulphate of ammonia	..	4,850	3,051	303	1,313
Other kinds	7,896	4,627	6,192	7,341	6,653
Total of manures including bones	58,293	48,381	52,700	40,571	34,198

TABLE 149. *Imports of Manures into India during 1929 to 1933*

		1929	1930	1931	1932	1933
Phosphatic manures—						
Superphosphates	Tons	(a) 29,325	(a) 29,257	2,910	3,781	2,463
	Rs.	*32,51,950*	*29,22,391*	*1,86,971*	*2,40,948*	*1,68,118*
Ammonium phosphate	Tons	..	..	85	791	975
	Rs.	..	..	*18,521*	*1,46,327*	*1,10,336*
Total of all manures	Tons	76,216	64,948	33,097	50,598	44,045
	Rs.	*97,37,364*	*74,90,491*	*34,95,470*	*51,86,681*	*43,71,681*

(*a*) Includes all phosphatic manures.

Rare Minerals.

[M. S. KRISHNAN.]

This title is used for a miscellaneous lot of minerals which do not fall conveniently under other heads. The adjective 'rare' should not be taken too literally, for some of the minerals are fairly common. But none of them occurs in quantities sufficient for extensive exploitation.

Platinum and Iridosmine.—Platinum and iridosmine have been found in the auriferous gravels of the rivers draining the slopes of the Patkoi ranges, both on the Assam and Burma flanks. Platinum used to be obtained, with gold, by the Burma Gold Dredging Co. from the gravels of the Irrawaddy above Myitkyina, but the Company went into liquidation in 1918, and there has been no production of this metal since then.

Recently, a small quantity of heavy sand obtained from the Myitkyina area was found to contain the mineral sperrylite, the arsenide of platinum. The source of the native metal and platinum minerals is presumably the ultrabasic intrusives known to be present in this region.

Molybdenite occurs in various parts of the Indian Empire. In Tavoy it is found:—

(*a*) in granite as an accessory mineral,
(*b*) in greisen bordering cassiterite and wolfram veins,
(*c*) in quartz veins with cassiterite and wolfram,
(*d*) in pegmatites, with the above minerals and sometimes scheelite,
(*e*) in veins in association with sulphide minerals.

The mineral is especially abundant in the Wagon region, at Kyaukanya and at Sonsin, which appears to be the only occurrence of type (*e*) so far known. The Sonsin deposit is the most promising one but no attempts have been made to recover the mineral by scientific processes. The small quantities which were formerly exported were obtained by laborious hand-picking.

Molybdenite occurs in crystalline rocks and in quartz in various parts of Chota Nagpur. It has been reported from Cherrapunji, Assam, where it occurs in a granite-gneiss. It has been found as scattered scales in the pegmatites intrusive into the khondalites in the Godavari Agency, Madras. A similar occurrence has been noticed in the aplite and pegmatite veins traversing the schistose

gneisses a mile-and-a-half east of Karadikuttam, west of Palni, Madura district, Madras. It occurs in an elaeolite-sodalite-cancrinite pegmatite at Mandoria near Kishengarh, Rajputana, and in a pegmatite at a depth of 2,500 ft. in the Balaghat lode, Ooregaum, Kolar goldfields. Disseminations of the mineral have also been observed in pyrrhotite occurring in the Travancore State.

An output of 7·5 cwts. valued at Rs. 1,407 was reported from Tavoy during the quinquennium 1919-1923, but no production has been reported since.

The use of molybdenum[1] dates practically from the Great War. The United States is the largest producer of molybdenite, the metal content of the concentrates produced in 1932 having been estimated at 2,450,000 lbs. The ores are now being treated by the flotation process. They are converted into ferro-molybdenum or calcium molybdate for use in industry. Molybdenum finds use in alloy steels, either alone or with other elements, *e.g.* manganese, chromium, nickel and vanadium. It eliminates temper brittleness, imparts hardness and preserves the desirable physical properties at high temperatures. The largest consumption of the alloys containing it is in the manufacture of highly stressed automotive structural parts. Chromium-molybdenum steels have high resistance to abrasion and are used in crushing and grinding equipment. Molybdenum is said to be replacing tungsten in high-speed tool steels to some extent. It is widely used in carburising steels and in grey, white, chilled and malleable cast iron. The salts of the metal are used in the pigment and colour industry, while the metal finds use in radio-tubes, X-ray equipment, etc.

Rutile, one of the natural forms of titanium dioxide, is widely distributed throughout many of the crystalline schists. It has been found in pieces of some size during exploratory work for mica in the neighbourhood of Ghatasher in the Narnaul district of Patiala State, Punjab.[2] P. N. Bose also reports the occurrence of this mineral in the vicinity of Kadavur in the Trichinopoly district of Madras. J. A. Dunn[3] reports it as often plentiful in the kyanite rock of Lapsa Buru, Singhbhum, but its separation would be difficult. It occurs, too, in considerable quantities in the black sands of the Travancore coast (*see* under *Ilmenite*), from which it is recovered in the zircon

[1] *Mining and Metallurgy*, p. 181, (1933).
[2] *Rec. Geol. Surv. Ind.*, XXXIII, p. 59, (1906).
[3] *Mem. Geol. Surv. Ind.*, LII, p. 221, (1929).

fraction. After magnetic separation the zircon sand is said to contain about 12 per cent. of rutile. On account of the similarity of specific gravity of the two minerals its separation is a matter of some difficulty. Rutile is, of course, more suitable for the preparation of titanium dioxide paints than ilmenite, and its price (94 per cent. grade) in New York in 1932 was \$160 per short ton.[1] Although the titania contained in bauxite is not present as the mineral rutile, attention may here be drawn to the fact that many Indian bauxites are rich in this oxide. When an aluminium industry is established in India, especially if the Bayer process be used, a new source of titania will be available in the by-product slimes.

Beryl, a silicate of aluminium and beryllium, occurs in the mica-pegmatites of the Kodarma forest in Bihar, of Nellore in Madras[2] and of Ajmer-Merwara,[3] Jaipur and Kishengarh in Rajputana.[4] It occurs sporadically in pegmatites in other parts of Bihar, in Assam and in Mysore. In Rajputana it is associated with the pegmatites of the Erinpura granite. In Ajmer-Merwara, the best deposit is that of Bisundni (25° 44′ : 75° 12′), the less important ones being those of Tehari, Shokla, Lohagal, Para and Kharwa. Toda Rai Singh in Jaipur and Govindsagar in Kishengarh also contain workable though small deposits. The slopes of the hills between Ajmer and Narwar used to show quantities of beryl weathered out of the pegmatites. Crystals up to 18 inches, and rarely even 27 inches, in diameter, are known to occur in some of the Rajputana deposits.

During the quinquennium under consideration, beryl has been mined independently of other minerals in Ajmer-Merwara. The production amounted to 1 ton in 1930, 281 tons valued at Rs. 5,281 (£397) in 1932 and 324 tons valued at Rs. 7,261 (£546) in 1933. The beryl, which contains 12·3 to 13·3 per cent. of BeO, was shipped to Hamburg at about £10 per ton *c.i.f.*, but recently the shipments to Germany have ceased because the chief buyers, Siemen & Halske, are understood to have discontinued the manufacture of beryllium. In 1934, the United States of America was the chief market for Indian beryl.

[1] *Mineral Industry*, Vol. 41, p. 518, (1933).

[2] *Cf.* V. S. Swaminathan, 'The Mode of Occurrence and Chemical Composition of Beryl from Nellore' *Trans. Min. Geol. Inst. Ind.*, Vol. XXII, p. 258, (1928).

[3] K. L. Bhola, 'Short note on the beryl deposits of Ajmer-Merwara' *op. cit.*, XXIX, pp. 127-139, (1934),

[4] A. M. Heron, 'Mineral resources of Rajputana' *op. cit.*, XXIX, pp. 299-304, (1935).

The current demand for beryl is due to the use of beryllium in copper alloys. The copper alloy containing 12·5 per cent. Be, which forms the base for the manufacture of industrial Cu-Be alloys, is gradually becoming cheaper ; it was selling in the New York market at \$50 in 1932 and at \$25 in 1933 per pound of beryllium content in the alloy. The most useful Cu-Be alloy is one containing 2 to 2·5 per cent. beryllium ; it can be cold-rolled ; it possesses great resiliency and resistance to fatigue which make it specially valuable in the manufacture of springs ; when heat-treated, the alloy develops a tensile strength of 220,000 lbs. per square inch. This high tensile strength is lost when the beryllium content exceeds 2·75 per cent. The alloy has the property of precipitating hardening to a remarkable degree and is valuable in the manufacture of non-sparking tools which are in demand by certain industries dealing with inflammable materials. Beryllium oxide is highly refractory, melting at 2750° C., and is an excellent electrical insulator even at high temperatures.

Gadolinite, a silicate of yttrium, beryllium and iron, has been found in a tourmaline pegmatite, associated with cassiterite, at Hosainpura in the Palanpur State, Bombay Presidency.

Allanite, a hydrous silicate of calcium, aluminium, iron and the rare earth metals, has been shown to occur in some of the pegmatites of the Nellore district (Sankara, Vadlapudi and Turpupundla) and near Palni in the Madura district, Madras. A mineral allied to allanite has been found near Kuruvikulam in the Tinnevelly district. It has also been recorded as occurring near Behea village in the Ranchi district, Bihar and Orissa.

Sphene, the titano-silicate of calcium, is often found as an accessory mineral in crystalline rocks. A large and beautiful crystal of a variety containing a noticeable percentage of cerium earths was obtained by Dr. A. M. Heron at Dadikar, five miles west of Alwar city in Rajputana, but its provenance is not known.

Sipylite, a niobate of erbium and other rare earth metals occurs in association with samarskite. It has been found in a mica-pegmatite about three miles to the north-west of Sankara mine and also in the Razulapad mica mine, both in the Nellore district.

Columbite-Tantalite, niobate and tantalate of iron and manganese, shows all compositions varying from the nearly pure niobate to the nearly pure tantalate, the specific gravity changing correspondingly from 5·3 to 7·3. The Indian occurrences are usually near the columbite end of the series, and have come chiefly from the

mica-bearing pegmatites. Beautiful crystals and very coarse bladed aggregates have been obtained from near Pichhli village[1] in the Singar *zamindari*, Gaya district, and also from the Kodarma area in the Hazaribagh district. At Pananoa hill, Monghyr, tantalite occurs as well as columbite; two specimens from here contained 37 to 52 per cent. of Ta_2O_5. Tantalite with over 60 per cent. of Ta_2O_5 has also been found recently in the Pichhli area. Columbite occurs also in the Madura, Nellore, Salem and Trichinopoly districts of the Madras Presidency; at Masti and other places in the Mysore State; [2] and near Machial about 20 miles from the Padar sapphire mines of Kashmir State.

Tantalum is still the more useful constituent of this mineral. It possesses the property of extreme resistance to all mineral acids, except hydrofluoric acid. Its avidity for common gases like hydrogen, oxygen and nitrogen has made it very useful in vacuum tubes in radio and X-ray work, and in neon lighting, where it acts as an absorbent of the gaseous impurities. It has the capacity of transforming alternating into direct current and has been used in the manufacture of electrodes, surgical instruments, laboratory apparatus, etc.

Until 1929 there was no demand for the niobium, but since then the niobium content of the mineral is also paid for by the buyers. A new cutting compound, called *vascoloy*, has been developed, containing vanadium, niobium or tantalium carbide cemented with tungsten or molybdenum under pressure. In high-chromium steels, niobium inhibits air-hardening and makes the steel ductile. In chromium-nickel steels the introduction of niobium, to the extent of 10 times the carbon present, imparts great resistance to corrosion.

Samarskite is a highly complex niobate and tantalate of metals of the cerium and yttrium groups, iron and uranium. It has been found in the Sankara mica mine (79° 47′ : 14° 15′) Nellore district, where Tipper[3] found masses weighing as much as 200 pounds. It has also been found at Tummalatalupur near Jogipalli Shrotriem in the same district. It has been recorded from Yedur in Mysore State and from Tavoy in Burma.

[1] G. H. Tipper, *Rec. Geol. Surv. Ind.*, L, pp. 260-261, (1919).

[2] *Rec. Mysore Geol. Dept.*, III, p. 182, (1900-1901); Mineral Resources of Mysore, p. 192, (1916).

[3] *Rec. Geol. Surv. Ind.*, XLI, p. 271, (1912).

Aeschynite, a titano-niobate of the cerium group of metals, has been found in a pegmatite in the Eraniel *taluk*, Travancore State.

Xenotime, yttrium phosphate, has been reported from Aru Buru, Kanyaluka *mauza*, Bihar, where it is associated with the apatite deposits. The orthorhombic optical character of the mineral is suggested by G. H. Tipper[1] to be due to its cerium content. *Pitchblende* or uraninite which may also contain other uranium minerals has been found at two localities in the Singar *zamindari* in Gaya district. The occurrence at Abraki Pahar near the village of Bhanen Kap has been known for some years.[2] Here it is associated with triplite, a phosphate of iron and manganese, in considerable quantities, and also with columbite and zircon. The pitchblende occurs as nodules in the pegmatite,[2] each nodule having an aureole of yellow 'uranium ochre'. Prospecting work did not reveal the presence of any large deposit. The second locality is near the village of Pichhli, where the occurrence is similar, the associated minerals being monazite, apatite and columbite.

Green and yellow encrustations containing uranium occur on the apatite-magnetite-rock at Sungi, Dhalbhum, Bihar and Orissa[3].

Vanadium.—Lenses and pockets of titaniferous magnetite are found near the boundary of Dhalbhum with Mayurbhanj State. Three samples from the Dublabera hill (22° 29′ : 86° 17′), sent by the Oriental Export and Import Company of Calcutta and analysed by the Imperial Institute of London, showed the following composition :—

	1	2	3
Fe_2O_3	71·90	60·50	67·76
TiO_2	13·06	14·00	25·01
V_2O_5	1·90	1·45	7·90

Some specimens collected by the officers of the Geological Survey of India from the same area did not show the presence of vanadium, The vanadium content must therefore be of irregular distribution.

Sillimanite.

[J. A. Dunn.]

It has been known for several years that 'sillimanite' was one of the dominant constituents of ceramic wares. This led to the realisation that the higher the raw materials were in Al_2O_3, *i.e.*,

[1] *Op. cit.*, LI, p. 31, (1921).
[2] *Mem. Geol. Surv. Ind.*, XXXIV, p. 31, (1901).
[3] *Rec. Geol. Surv. Ind.*, L, p. 15, (1919).

the nearer they approached the composition of sillimanite the more highly refractory would be the resulting products. This suggested to several investigators the use of sillimanite, $Al_2O_3.SiO_2$, in the actual mix. Large supplies not being available, the attempt was made in 1920 to manufacture artificial sillimanite. During 1924, Bowen & Greig showed that sillimanite could not be made artificially and that the true composition of the artificial 'sillimanite', found in all ceramic wares, was $3Al_2O_3.2SiO_2$, which they called 'mullite'. They then found that natural sillimanite itself breaks up into crystals of mullite above a temperature of 1,545°C. Later Greig found that, besides sillimanite, kyanite and andalusite also broke up into mullite with the concomitant formation of a siliceous glass (probably cristobalite) on heating above certain definite temperatures. Of the three minerals, kyanite alters at the lowest temperature, sillimanite at the highest. In the case of kyanite the change is accompanied by a considerable change in volume, but with andalusite and sillimanite the increase in volume is very small. Further investigations led to the conclusion that the mullite was the important material in aluminous refractories, and that this mullite could be derived either from kyanite or sillimanite. Owing to its expansion on heating, kyanite could only be used after it had been converted in kilns to mullite, whereas sillimanite can be used immediately in the raw state. Ceramic materials and refractory bricks made from these materials possess the following properties: strength and toughness, high melting point (about 1,810°C.) and stability up to that temperature, low co-efficient of expansion, low electrical conductivity, freedom from volume changes, neutral reaction and resistivity to corrosive slags and to oxidising and reducing conditions.

To the ceramic industries mullite appears to have many uses, whether it be derived from sillimanite or kyanite. Electrical porcelains made from it are very tough and strong and have a very low conductivity. It has been used in sparking plugs. It is finding a wider use as a refractory brick where the furnace conditions are severe as in boiler furnaces, combustion chambers, and particularly in glass manufacture. It is not likely to find any application in such metallurgical processes where it would come in contact with metallic slags, as it fuses readily under the action of metallic oxides.

In India, kyanite occurs mainly in Singhbhum, Bihar and Orissa, and sillimanite in Nongstoin State, Assam, and at Pipra in Rewah State, Central India. The mining future of these refractory mate-

rials in India seems to be dependent upon two factors, *viz.*, the favourable outlook with which the users may accept the materials, and the producer's ability to place them sufficiently cheaply on the market. At present the chief market is on the Continent, particularly Czechoslovakia. The price of sillimanite in England has fluctuated between £11 and £14 per ton. So far, the market has not been impressed sufficiently to take up the use of the material whole-heartedly; and it would be advisable for the Indian producers concerned to sell at the minimum price in order to widen the market.

The occurrence of the deposits of sillimanite in Assam became known in a curious way. During the war a deposit of corundum was being mined by the Khasi Mines Company, at Sona Pahar, Nongstoin State, Assam. In 1921, Messrs. Pawle and Brelick, the agents for the company in England, found that the hardness of a consignment was very unsatisfactory and a chemical and microscopical examination was made by Messrs. G. T. Holloway of Limehouse. It was thought that the material was mainly sillimanite, which opinion was confirmed by Dr. C. S. Fox, who was at that time attached to the Indian Trade Commissioner of London.

The occurrence of corundum in Assam was known to Mallet[1] in 1879, and other later investigators[2] have referred to the deposits. In order to clear up the relation of the sillimanite to corundum in these deposits, Dr. Dunn visited the area in December, 1926, and January, 1927. His descriptions of this deposit and other sillimanite and kyanite deposits in India have since been published.[3]

The deposits of sillimanite at Sona Pahar in Assam may be reached as follows: by motor lorry from Gauhati to Boko 36 miles to the west, thence 12 miles south by bullock cart to Haima at the foot of the Khasi hills, and finally some two days' march south into the hills for 23 miles.

The area is on the Khasi plateau and the height above sea-level about 3,000 feet. The sillimanite-corundum deposits are associated with such highly aluminous rocks as cordierite-biotite-quartz-microcline gneiss and sillimanite quartz-schists. The majority of the deposits consist mainly of massive sillimanite with a little corundum; one or two are almost entirely of corundum and several are entirely

[1] F. R. Mallet, *Rec. Geol. Surv. Ind.*, XII, p. 172, (1879).

[2] F. E. Jackson, *op. cit.*, XXXVI, p. 323, (1908); *op. cit.*, LV, p. 27, (1924).

[3] J. A. Dunn, *Mem. Geol. Surv. Ind.*, LII, (1929).

of sillimanite. Impurities are not abundant and consist mainly of rutile, a very little biotite and some iron ore. There are some thirteen different known deposits, occurring over a belt about 3 miles long by 1 mile wide. In estimating the quantity of material available, it is difficult to arrive at any definite quantity owing to the peculiar mode of occurrence of the individual deposits, and to the fact that a very large amount of the material is completely decomposed. However, reckoning down to a depth of only 10 feet there is at least a total minimum quantity of 83,000 tons available. The actual quantity may be many times this amount. These deposits are, however, very unfavourably situated, and under present conditions transport charges would be high—about Rs. 56 per ton to the Brahmaputra river.

The deposit of corundum-sillimanite in Rewah State, Central India, is near Pipra, a small village in the extreme south-east of the state, about 5 miles from its eastern and southern boundaries. The deposit is associated with sillimanite-schists and pyroxene-bearing rocks. The bed of corundum is about ½ mile long by about 70 yards wide. Reckoning on an average depth of 30 feet, the total quantity of corundum available is estimated to be 100,000 tons. Of sillimanite there is about 100,000 tons of good material, but the possibility of exploiting the better class sillimanite is limited, owing to its intimate admixture with impure material. This deposit also suffers from the disadvantage of high freight charges to Calcutta. At present the material is carried by bullock pack to Mirzapur, about 120 miles.

Other small unimportant deposits of corundum and sillimanite occur in the Bhandara district of the Central Provinces.

Recently, sillimanite-rock has been found to occur in the southern end of Hsipaw State, Burma.

The following analyses are of typical sillimanite-rock from Assam and Rewa State.

	Assam. Per cent.	Rewa. Per cent.
SiO_2	36·26	33·40
Al_2O_3	61·59	59·49
Fe_2O_3	1·26	0·94
TiO_2	0·15	0·19
CaO	trace	trace
MgO	0·16	0·14
MnO	..	0·39
Water	..	6·12
	99·42	100·67
Sp. gr.	3·27	3·122

Slate.

[E. R. GEE.]

Slate-quarrying gives a means of livelihood to numbers of workers along the outer Himalaya, where the foliated rocks, though often not true clay-slates, possess an even and perfect fissility, which enables them to be split for slabs and even fine roofing slates at Kanyara. In the Kangra district, at Kanyara, work is being carried on in a systematic manner by the Kangra Valley Slate Company, Limited. The occurrences of this area have been recently described by Mr. D. P. Chandoke.[1] The same company works quarries in clay-slates amongst the Aravalli series near Rewari in the Gurgaon district south of Delhi. There are in addition several smaller companies working slate in the Kangra and Gurgaon districts. An account of the deposits of Gurgaon and of other occurrences of Rajputana is given in Dr. Heron's recent paper.[2]

In the Kharakhpur hills, Monghyr district, Bihar, the properties held by Messrs. C. T. Ambler & Company were transferred to a limited company, Ambler's Slate and Stone Company, in 1913. The slate worked is often slightly phyllitic and is probably of Dharwarian age; it is now practically only used for terraced roofing. Enamelled slate slabs for electrical purposes and switch-boards and fuse bases are manufactured but the demand is very small as the slate is not as suitable as the Welsh slate for that purpose. Since the advent, during the previous quinquennium, of cheap school slates from Germany made of thin sheet steel, blackened and stoved, their manufacture in India has been discontinued as it has been impossible to compete with the former. Competition from cheap aluminium and enamelled wares has also driven the small slate dishes and curry platters for native use off the market. Some of the quarries held by this company date back to ancient times, and probably yielded the very fine piece of slate from which the throne of the Nawabs Nazim of Bengal, now shown in the Indian Museum, was fashioned.

Extensive occurrences of slate, quarried in places, are also reported from the Panch Mahal district, Bombay Presidency.[3]

[1] *Trans. Min. Geol. Inst. Ind.*, Vol. XXVIII, Pt. 2, pp. 161-176, (1933).

[2] *Op. cit.*, XXIX, Pt. 4, pp. 331-333, (1935).

[3] *Rec. Geol. Surv. Ind.*, LXVII, p. 25, (1933); LXVIII, p. 30, (1934).

TABLE 150.—*Production of Slate during the years 1929 to 1933.*

	1929		1930		1931		1932		1933		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Bihar and Orissa—												
Monghyr . . .	(a)3,564	*(a)89,099*	1,206	*35,116*	2,050	*65,628*	1,345	*41,785*	1,689	*45,096*	1,971	*55,345*
Singhbhum . . .	..	..	27	*669*	183	*2,346*	193	*2,239*	123	*1,160*	105	*1,253*
Mysore—												
Kadur	..	..	..	..	..	..	15	*45*	..	..	3	*9*
Tumkur . . .	..	..	..	..	..	..	..	..	8	*40*	2	*8*
Punjab—												
Gurgaon . . .	813	*15,859*	1,277	*20,969*	1,632	*19,527*	1,531	*15,360*	1,381	*15,699*	1,327	*17,483*
Kangra . . .	4,520	*1,20,124*	5,193	*1,23,631*	4,134	*1,09,263*	4,619	*1,13,422*	4,933	*1,11,453*	4,680	*1,15,578*
Keonthal . .	222	*1,011*	125	*515*	..	..	110	*490*	195	*595*	130	*522*
Rajputana— Alwar	180	*750*	210	*860*	315	*1,290*	360	*1,260*	1,157	*7,700*	444	*2,372*
United Provinces—												
Almora	174	*990*	134	*154*	149	*3,665*	..	..	..	..	91	*962*
Banda	..	..	..	..	..	..	..	..	1,650	*8,162*	330	*1,632*
Garhwal . . .	149	*297*	331	*662*	237	*474*	177	*354*	241	*482*	227	*454*
Naini Tal . . .	4	*6*	2	*3*		.	..	..	..	..	1	*2*
TOTAL .	**9,626**	*2,28,136*	**8,505**	*1,82,579*	**8,700**	*2,02,193*	**8,350**	*1,74,955*	**11,377**	*1,90,387*	**9,811**	*1,95,650*
Total value in sterling .		*17,025* (£1 = Rs. 13·4)		*£13,524* (£1 = Rs. 13·5)		*£14,977* (£1 = Rs. 13·5)		*£13,154* (£1 = Rs. 13·3)		*£14,315* (£1 = Rs. 13·3)		..

(a) Revised figure.

Slate of good quality and in considerable quantity was observed in the valley of the Tuzu river, some 25 miles east of Kohima, in the Naga Hills.[1] The locality is just within the borders of our administered territory, but is somewhat remote for present-day exploitation. It is used by the half-civilised local tribes for roofing, mill-stones and other purposes. Slate is also being worked in various parts of the so-called transition series of rocks of the Peninsula. Slate deposits are also exploited locally in Kashmir State.[2]

Such production figures as are available are given in Table 150; it will be observed that, compared with 1924-1928, the average annual production decreased by 27 per cent., though the average price for the quinquennium rose from about Rs. 14 to Rs. 21 per ton.

Sodium compounds (other than Salt).

[E. R. GEE.]

Beside sodium chloride, other salts of soda, notably the sulphate (*khari*) and carbonate (*saji*), accumulate in the soil of many areas in India where the climate is dry, giving rise to the alkaline efflorescence known as *reh*, which renders large areas quite sterile. Both the sulphate and carbonate are also prominent amongst the sodium compounds in the brine of the Rajputana salt lakes. Carbonate of soda occurs in considerable quantity in the water of the Lonar lake and in the lakes of Eastern Sind.

Alkaline soils.

A general account of the alkaline deposits (*reh, saji mati, khari*) used in India is to be found in the *Agricultural Ledger*, No. 5 (Reporter on Economic Products, Calcutta, 1902) and in J. W. Leather's 'Investigations on Usar Land' (Allahabad, 1914).

Usually sodium carbonate predominates, but in many places sodium sulphate is the chief constituent. In Bihar, the districts producing are Champaran, Muzaffarpur and Saran. *Saji mati* is also recovered at the present time from many parts of the United Provinces. Further details are given in the review for the previous quinquennium.[3]

[1] E. H. Pascoe, *Rec. Geol. Surv. Ind.*, XLII, p. 263, (1912).
[2] *Min. Surv. Repts., Jammu & Kashmir Govt.*, Non-metallic minerals of Jammu and Kashmir, pp. 37-40, (1930).
[3] *Rec. Geol. Surv. Ind.*, LXIV, p. 432, (1930).

An idea of the extent of the deposits in the United Provinces may be gathered from a paper by E. R. Watson and K. C. Mukerjee,[1] where also several analyses of the soils and recovered products may be found. By what is probably an optimistic method of extrapolation they calculated 'that 7,321,000 tons of crude soda, containing 4,888,000 tons Na_2CO_3 could be obtained annually from the visibly efflorescent areas in this province'.

The method of extraction usually adopted is very similar to that used in the recovery of saltpetre.

Saji mati is used for soap making and for washing clothes. The *khari* variety, containing more sodium sulphate, is largely used by tanners, who claim that it produces a softer leather than treatment with pure materials.

Lonar Lake.

Soda occurs in the bed of a remarkable lake in Berar, the Lonar lake (19° 59′ : 76° 34′), situated in a depression in the Deccan trap. The depression is nearly circular, about a mile in diameter and 300 feet deep; at the bottom there is a shallow lake of saline water, which varies in size and density according to the season of the year, and rests on a stratum of alkaline mud of unknown depth. In 1910 (no later estimates are available) the lake water contained about 2,000 tons and the upper five feet of mud about 4,500 tons of alkali, reckoned as sodium carbonate.[2] From the lake water, products of varying degrees of purity are recovered by crude fractional crystallisation, the best of them, *dalla*, having a composition approaching that of the natural mineral urao, $Na_2CO_3 . NaHCO_3 . 2H_2O$. As in the previous quinquennium, only a very small production was obtained from this source during the period 1929 to 1933. Messrs. The Pioneer Alkali Works, Ltd., having gone into liquidation in 1929, annual leases were given in 1930 and 1931 for Rs. 700 and Rs. 100 respectively. No production figures are available for the former year; whilst during 1931, about 50 *khandis* of mineral (1 *khandi*=20 maunds) were reported. After 1931, a triennial lease was given on an annual premium of Rs. 500. Up to the end of the quinquennium, owing to excessive water in the lake, no minerals were extracted. The products obtained during 1930 and 1931 were generally used for washing clothes and for soap manufacture. Some

[1] *Journ. Ind. Industries and Labour*, Vol. II, p. 13, (1922).

[2] T. H. D. La Touche and W. A. K. Christie, *Rec. Geol. Surv. Ind.*, XLI, p. 280, (1912).

of the output is said to have been exported to Bombay, Madras and Amalner.

Alkaline lakes of Khairpur and Sind.

Soda is collected during the hot weather from a large number of alkaline lakes or '*dhands*' in the Indian state of Khairpur and in eastern Sind. These have been described by G. de P. Cotter,[1] and an account of them, condensed from Dr. Cotter's memoir, was given in the quinquennial review for 1919 to 1923.[2] The lakes are situated in depressions among the sandhills and their waters contain varying amounts of carbonate, chloride and sulphate of sodium. On evaporation there is obtained a crude form of urao, $Na_2CO_3.NaHCO_3.2H_2O$, locally known as *chaniho*. According to Dr. Cotter, its principal use is in the preparation of light biscuits, but it is also used for washing clothes, in hardening treacle, in soap making, and in the preparation of *goorakho* tobacco. From Table 151, it will be observed that the production of Khairpur State increased appreciably during the quinquennium under review. The average annual output for 1924-28 to 1928-29 was 751 tons; the corresponding figure for 1929-30 to 1933-34 was 1,043 tons.

TABLE 151.—*Production of Chaniho in Khairpur State during the years 1929-30 to 1933-34.*

Year.	Production in tons.	Number of '*dhands*' producing.
1929-30	170	9
1930-31	1,160	47
1931-32	606	32
1932-33	1,239	39
1933-34	2,041	25
Average .	*1,043*	*30*

[1] *Mem. Geol. Surv. Ind.*, XLVII, Pt. 2, (1923).
[2] *Rec. Geol. Surv. Ind.*, LVII, pp. 386-388, (1925).

In the Nawabshah district in Sind, 129 tons were recovered in 1928-29, 117 in 1929-30, 110 in 1930-31, 114 in 1931-32 and 92 tons in 1932-33.

A large proportion of the *chaniho* recovered is exported from Karachi, mainly to Arabia, Bombay and Aden.

Parantij, Ahmedabad district, Bombay.

In a recently-published note,[1] Dr. P. K. Ghosh described the soda (*reh*) deposits and the manufacture of caustic soda and crude soap at Parantij, Ahmedabad district, Bombay. The deposit, which consists largely of sodium carbonate with sodium chloride, forms an efflorescent growth on the surface of the soil and alluvium in the upper part of the Bokh valley and in the banks of the Khari river. The raw saline material, together with local deposits of *kankar* and *mohua* (Bassia latifolia) oil, supports a local industry for the manufacture of washing-soap.

'Soap-sand,' Burma.

In certain portions of the dry zone of Burma, in the Shwebo, Chindwin and Myitkyina districts, an efflorescent deposit, consisting largely of salts of sodium, mainly the carbonate, is formed on the surface of the soil. This crude soda product is known as '*sapaya*' or 'soap-sand' and is used and sold locally for washing purposes, etc.[2] The production of this salt during the quinquennium under review is given in the following table.

TABLE 152.—*Production of Soap-sand in Burma.*

Year.	Tons.	Rs.	£.
1929	2,777	10,492	(*a*) 783
1930	2,832	11,982	(*b*) 888
1931	2,685	8,954	(*b*) 663
1932	2,250	6,946	(*c*) 522
1933	3,882	17,812	(*c*) 1,330
Average .	*2,885*	*11,237*	*839*

[1] *Rec. Geol. Surv. Ind.*, LXVIII, Pt. 2, p. 242, (1934).
[2] *Op. cit.*, LXII, p. 67, (1929); LXIII, p. 54, (1930); LXV, p. 66, (1931).
(*a*) £1=Rs. 13·4. (*b*) £1=Rs. 13·5. (*c*) £1=Rs. 13·3.

TABLE 153.—*Value and destination of exports of Chaniho from Karachi during the years 1931-32 to 1933-34.*

—	1931-32	1932-33	1933-34
	Rs.	Rs.	Rs.
FOREIGN COUNTRIES—			
Aden and Dependencies	28,129	28,622	24,475
Bahrein Islands	85	169	135
Ceylon	1,421	1,186	1,677
Zanzibar	15	30	33
Kenya Colony	20	7	19
Iraq	20	..	..
Maskat Territory and Trucial Oman	1,855	1,010	1,313
Other Native States in Arabia	36,470	39,218	32,833
Persia	246	535	530
Italian East Africa	2,592	3,440	4,600
COAST PORTS—			
Bengal	..	90	75
Bombay	44,449	14,568	41,888
Madras	17,529	17,589	29,819
Burma	36	27	38
Baluchistan Agency Tracts	39	41	15
Cutch	2,527	2,705	1,953
Kathiawar	20,541	16,643	16,179
Goa	563	979	532
TOTAL	**1,56,537**	**1,26,859**	**1,56,114**

Sambhar Lake.

As a potential source of sodium salts other than the chloride, the Sambhar salt lake in Rajputana may be mentioned. The lake dries up nearly every year, but the brine formed when it fills in the rainy season has a fairly uniform composition from year to year. The residue on evaporation contains about 86 per cent. sodium chloride, 10 per cent. sodium sulphate and 4 per cent. sodium carbonate. In the mother liquors from salt manufacture the percentage of sulphate and carbonate are, of course, much greater. As the upper 12 feet of the lake mud contain some 50 million tons of sodium chloride, it is reasonable to conclude that there are several million tons of sodium sulphate and carbonate similarly stored.

Manufacture of soda from salt.

An important development of the previous quinquennium was the building of a large soda factory in the Indian state of Dhrangadhra on the Little Rann of Cutch. The Shri Shakti Alkali Works was intended to produce annually the equivalent of 22,000 tons

of sodium carbonate by the ammonia soda process. Salt is, of course, available in unlimited quantities on the Little Rann, and limestone was obtained from Jasdan. An attempt to get the works into operation in July, 1928, was unsuccessful, and subsequent efforts have proved similarly abortive.

Magadi Soda Company.

The Magadi Soda Company went into liquidation nearly ten years ago. The company had a plant at Budge Budge near Calcutta for the manufacture of caustic soda from sodium carbonate imported from the Magadi lake in Kenya Colony where huge natural deposits occur. The works at Budge Budge are closed down, and it is at present still unlikely that the industry will be revived. Heavy freight on suitable limestone was one of the factors that made it difficult for the company to compete with imported caustic soda.

Imports.

The imports of alkalies for the years 1929 to 1933 are given below.

TABLE 154.—*Imports of Alkalies.*

Year.	Sodium carbonate.	Caustic soda.	Sodium bicarbonate.
	Tons.	Tons.	Tons.
1929	57,781	9,285	5,953
1930	51,953	11,122	5,068
1931	54,240	12,964	4,899
1932	58,006	13,788	4,698
1933	49,420	14,810	4,360
Average annual production .	*54,280*	*12,394*	*4,996*

Compared with the previous quinquennium, the average annual imports of sodium carbonate again increased, in the present instance by 14·0 per cent.; there was also a marked rise of 66·6 per cent. in the amount of imported caustic soda.

Imports of nitrate of soda during the period 1929 to 1933 are as follows :—

TABLE 155.—*Imports of Nitrate of Soda.*

	Tons.	Value (in Rs.).
1929	12,427	17,21,227
1930	4,237	5,83,869
1931	1,238	1,56,158
1932	1,767	2,28,112
1933	1,970	2,30,139
Annual average	4,328	5,83,901

Nitrate of soda comes into compositions as a fertiliser with ammonium sulphate, the production and imports of which are given on pages 451 and 448.

Steatite.

[E. R. GEE.]

General.

One of the most widely distributed minerals in India is steatite (talc) either in the form of a coarse potstone—so called on account of its general use in making pots, dishes, etc. —or in the more compact form, suitable for carvings, and, in its best form, suitable for the manufacture of gas-burners. Cooking utensils of steatite are much in request by high-caste Hindus, since after use they can be purified by fire and communicate no unpleasant taste to food. There is a trade of undetermined extent in nearly every province, but it is in most cases impossible to form even a rough estimate of its value. One of the principal uses of steatite in India is as a polishing agent in rice-milling.

Within recent years steatite bricks have come into increasing use as a special type of refractory, where resistance to corrosion, especially by highly alkaline slags, is the primary consideration; they are also used in the Wagner alkali smelting furnace at the recovery end of a paper mill.

Occurrences.

An exhaustive account of the Indian occurrences of steatite was published by Mr. F. R. Mallet in the *Records, Geological Survey of India*, Vol. XXII, Pt. 2, (1889); and a later note[1] adds further details with regard to the deposits in the Minbu district, Burma. In 1911-12, Mr. C. S. Middlemiss[2] discovered a large deposit of steatite of very fair quality near Dev Mori in Idar State, Bombay Presidency, associated with various other magnesian minerals (actinolite, magnesite, serpentine and asbestos). He estimates the bed of steatite to be over 1 mile long with a width of over 200 feet and a vertical dip. On this basis it is calculated that 2 million tons are obtainable in the first 20 feet from the surface. Dr. A. M. Heron has collected notes on some hitherto undescribed steatite deposits in Jaipur State, Rajputana,[3] a detailed description of the occurrences and production will be found in a recent paper by him.[4] The principal localities are: Dogetha, 2½ miles N. E. of Raialo; Gisgarh; and Morra-Bhandari. In the last mentioned area one of the beds measures 25 feet in thickness, and pockets of steatite extend over a distance of 5 miles. The steatite is of very good quality, milky-white or faintly tinged with green. In recent years, a grinding mill has been installed at Dausa and supplies the pulverised mineral to the soap industry of the Punjab, to paper, paint and rice mills and for export abroad.

The steatite deposits on the north side of the Marble Rocks in the Jubbulpore district form pockets in the dolomite of the gorge. They were formerly worked by native methods with a small annual production, but are now held on mining lease by Messrs. Burn and Company who have erected a grinding mill in their pottery works at Jubbulpore and are converting their steatite into powder; deposits at Gowari and Lalpur on the south side of the Narbada have been secured by the Bombay Mining and Prospecting Syndicate. Steatite is also reported to occur in considerable quantity in a hill not far from Rupaund, a few miles from the Katni-Bilaspur line of the Bengal Nagpur Railway.

Small quantities of steatite were formerly excavated in the Pakokku Hill tracts of Burma and were used for pencils. In former years, steatite was also produced in the Minbu district. The

[1] H. H. Hayden, *Rec. Geol. Surv. Ind.*, XXIX, p. 71, (1896).
[2] *Op. cit.*, XLII, p. 52, (1912).
[3] H. H. Hayden, *Rec. Geol. Surv. Ind.*, XLIII, p. 21, (1913).
[4] 'The Mineral Resources of Rajputana', *Trans. Min. Geol. Inst. Ind.*, Vol. XXIX, Pt. 4, pp. 375-379, 406, (1935).

mines have been described by the late Sir Henry Hayden[1] and are situated some 30 miles west of Hpa-aing.

Recent references to deposits of talc in Dhalbhum, Bihar and Orissa, in Udaipur State, Rajputana, and in the Nellore district, Madras, are included in the General Reports of this Department published since 1929.[2]

The late Mr. A. Ghose opened up the steatite deposits at Muddavaram and Musila Cheruvu near Betamcherla in the Kurnool district, and took out a mining lease in 1912. The quality of the deposit was apparently good and the mineral at first fetched a good price. Later, however, production diminished and no output is recorded for the period 1929 1933.

A small output is also reported from Nalgonda and Nirmal in Hyderabad State.

Steatite in compact form occurs as veins in the Great Limestone in the vicinity of Riasi, Kashmir State. It has been used locally in the manufacture of cups and bowls.[3]

Such figures as are available for the output of Indian steatite are summarised in Table 156. The values assigned to the mineral vary between very wide limits, and although this is no doubt partly due to differences in the value of the product, according to the use to which it is put, yet some of the figures are probably only rough estimates.

Production.

During the period under review, the average annual output of steatite increased by 16·6 per cent. as compared with the quinquennium 1924-1928, when the figure was 7,333 tons. On the other hand, the average value has decreased slightly from about Rs. 22·0 per ton to Rs. 21·5. During the early part of the quinquennium prices were good, but they diminished considerably during the period 1932-1933.

Production reached the high figure of over 17,000 tons in 1933. Of the more important producers, Jaipur State retained the lead until that year, when its production figure of 6,151 tons was exceeded by that of Hamirpur, United Provinces, the output from which source had, until that date, been relatively insignificant. Of the other principal producers, the average annual output from

[1] *Rec. Geol. Surv. Ind.*, XXIX, pp. 71-76, (1896).

[2] *Op. cit.*, LXIII, p. 54, (1930); LXV, p. 67, (1931); LXVIII, p. 47, (1934).

[3] *Min. Surv. Reports, Jammu & Kashmir Govt.*, Non-metallic minerals of Jammu & Kashmir, p. 44, (1930).

TABLE 156.—*Production of Steatite in India during the years 1929 to 1933.*

—	1929		1930		1931		1932		1933		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Bihar and Orissa—												
Hazaribagh . . .	..	..	..	..	..	..	..	..	452	*6,000*	(a)	(a)
Mayurbhanj . . .	72	*7,000*	41	*3,950*	27	*2,600*	..	..	6	*578*	(b) 37	(b) *3,532*
Seraikela . . .	13	*720*	12	*640*	37	*1,000*	..	..	..	..	(c) 21	(c) *787*
Singhbhum . . .	349	*11,491*	208	*3,496*	442	*7,746*	152	*760*	656	*3,706*	361	*5,440*
Central India—												
Bijawar State . .	110	*4,500*	33	*1,350*	74	*1,200*	119	*2,430*	60	*2,700*	79	*2,436*
Central Provinces—												
Jubbulpore . . .	1,541	*24,506*	2,209	*30,327*	188	*4,077*	402	*9,480*	1,154	*6,088*	1,099	*14,896*
Madras—												
Nellore	17	*176*	35	*1,910*	50	*1,000*	41	*1,909*	30	*1,650*	35	*1,329*
Salem	253	*6,005*	220	*3,488*	147	*3,075*	179	*2,855*	214	*3,365*	203	*3,754*
Mysore State . . .	50	*300*	110	*562*	79	*574*	133	*542*	115	*814*	97	*558*
Rajputana—												
Ajmer-Merwara . .	..	..	15	*105*	25	*169*	..	..	..	..	(d) 20	(d) *137*
Jaipur State . . .	4,400	*2,06,000*	3,927	*1,58,225*	3,915	*93,884*	5,172	*1,07,220*	6,151	*1,28,643*	4,713	*1,38,794*
United Provinces—												
Hamirpur . . .	412	*15,785*	47	*2,033*	151	*6,183*	314	*4,294*	7,275	*25,429*	1,640	*10,745*
Jhansi	..	..	..	..	..	..	..	..	935	*3,991*	(a)	(a)
TOTAL .	**7,217**	*2,76,483*	**6,857**	*2,06,056*	**5,135**	*1,21,508*	**6,512**	*1,29,490*	**17,048**	*1,82,964*	**8,554**	*1,83,306*
Total value in sterling .		*£20,633* (£1 = Rs. 13·4)		*£15,266* (£1 = Rs. 13·5)		*£9,001* (£1 = Rs. 13·5)		*£9,736* (£1 = Rs. 13·3)		*£13,757* (£1 = Rs. 13·3)		*£13,679*

(a) Not taken into average.
(b) Average of 4 years.
(c) Average of 3 years.
(d) Average of 2 years.

Jubbulpore declined by about 9 per cent. as a result of very small productions during 1931 and 1932, whilst the annual average for Singhbhum fell from 678 tons during 1924-28 to 361 tons during the quinquennium under review.

Sulphur, Sulphuric Acid and Soluble Sulphates.

[A. M. HERON.]

Occurrence of sulphur.

Small quantities of sulphur are obtainable on the dying volcano of Barren Island in the Bay of Bengal, in the State of Kalat in Eastern Baluchistan, and on the Koh-i-Sultan and neighbouring volcanoes in Seistan and Eastern Persia. The Kalat sulphur mine near Sanni, which was formerly worked to some extent, was recently examined and the available sulphur estimated at 10,000 tons[1]; this is a conservative estimate, but even if the actual amount be several times greater, the deposit cannot be regarded as of serious potential value, since it represents little more than a year's supply. India is likely, therefore, to be ultimately dependent for her acid on by-products from the reduction of metallic sulphides.

Utilisation of sulphides.

In a previous review (*Rec. Geol. Surv. Ind.*, Vol. LII, page 321) it was reported that a scheme was on foot for the erection of a plant at Jamshedpur to treat the zinc concentrates of Bawdwin. The projected initial capacity of the plant was to be some 30,000 tons annually, but as a cheap supply of acid would be the key to many industries, there is no doubt that a very much larger output would be readily absorbed. The absence of such industries was seriously felt during the war. Thus the average annual value of imported bleaching materials alone during the five years 1914-1918, was £88,709 : for this import, formerly brought from Europe, India was dependent on Japan. The average value of bleaching powder annually imported between 1929 and 1933, was Rs. 8,62,180. The abandonment of the project referred to above has, unfortunately, pushed into the future the possibility of any considerable advance towards making India self-contained in the matter of the more essential chemical manufactures.

[1] G. de P. Cotter, *Rec. Geol. Surv. Ind.*, L, p. 137, (1919).

Importation of sulphur.

A considerable amount of acid is already manufactured in India, but the industry is dependent entirely on imported sulphur. This used formerly to come from Sicily, but from 1917-18 to 1919-20, most of India's imports were derived from Japan. In 1920-21, Italy began to regain her former place, and maintained it during the quinquennium under consideration; the next most important source is Germany. The imports of sulphur during the five years 1929 to 1933 are shown in Table 157 and averaged 18,006 tons annually, valued at Rs. 18,40,589, as compared with an annual average of 15,788 tons valued at Rs. 15,74,014, for the period of the previous review.

TABLE 157.—*Imports into India of Sulphur, Sulphuric Acid, Ammonium Sulphate, Ammonia and Salts thereof, during the years 1929 to 1933.*

Year.	Sulphur.	Sulphuric acid.	Sulphate of ammonia.	Ammonia and salts thereof (anhydrous or otherwise).
	Tons.	Tons.	Tons.	Tons.
1929	19,223	427	23,901	1,858
1930	18,674	970	21,859	1,524
1931	15,728	220	14,996	1,452
1932	16,192	371	32,640	2,022
1933	20,212	232	32,875	1,978
TOTAL	90,029	2,220	126,271	8,834
Average	*18,006*	*444*	*25,254*	*1,767*

Imports of sulphuric acid.

The average annual import of sulphuric acid was 444 tons, valued at Rs. 68,764, as compared with 118 tons valued at Rs. 44,344 during the previous five years. 182 tons valued at Rs. 1,15,905 during the quinquennium 1919-1923, 396 tons valued at

Rs. 1,14,585 during the quinquennium 1914 to 1918, and 3,188 tons valued at Rs. 5,86,305 during the quinquennium 1909 to 1913. This decrease in imports of sulphuric acid compared with 1909-1913 is due to the increased production of this chemical at numerous plants in India.

Production of sulphuric acid.

The acid as manufactured at different plants varies in strength from 65 to 95 per cent. H_2SO_4, according to the purposes for which it is required. The data of production available have accordingly been reduced to the uniform basis of 100 per cent. acid, and are summarised in Table 158.

TABLE 158.—*Production of Sulphuric Acid in India during the years 1929 to 1933.*

(Statute tons in terms of 100 per cent. acid.)

Provinces.	1929	1930	1931	1932	1933	Total for 1929-33
Bengal . . .	9,235	8,315	6,530	6,739	6,351	37,170
Bihar and Orissa .	11,770	12,383	11,297	9,662	10,699	55,811
Bombay . . .	2,140	2,037	4,181	4,013	4,473	16,844
Burma . . .	5,590	7,328	5,216	5,062	4,259	27,455
Madras . . .	1,289	1,168	598	981	548	4,584
Punjab . . .	274	321	539	698	731	2,563
United Provinces[1] .	1,666	1,743	2,003	2,459	2,367	10,238
TOTAL	*31,964*	*33,295*	*30,364*	*29,614*	*29,428*	154,665

[1] Excludes production of Acid Mills, Lucknow, amounting to 8 tons in 1929, 36 tons in 1930 and in 1931, 31 tons in 1932, and 26 tons in 1933; also of S. H. Abdul Rashid Chemical Works, Benares, amounting to 171 tons in 1929, 108 tons in 1930 and 40 tons in 1931; the latter firm closed down since June, 1932. These figures have not been included in the above Table as the composition of the acid is not known.

During the four years 1919-1922, the annual production was a little under 12,000 tons, but in 1923 the production jumped to 17,127 tons of 100 per cent. acid, giving an annual average for the quinquennium of 12,835 tons. This was followed by the greatly increased average annual production of 28,425 tons during the period 1924-1928, increased still further to 30,932 tons during the period under review. This increase of recent years is mainly due to the increased recovery of by-product ammonia as ammonium sulphate at the coking plants, iron and steel works, and collieries in the provinces of Bengal and Bihar and Orissa. The production of sulphuric acid in Bihar and Orissa is mainly for the manufacture of ammonium sulphate, as will be seen from the fact that the total ammonium sulphate produced in this province during the quinquennium reached the figure of 44,784 tons.

Producers of sulphuric acid.

The producers of sulphuric acid are as follows, the figures being the total production of acid at 100 per cent. during the period under review :—

	TONS.
Bengal—	
D. Waldie & Co., Konnagar	7,100
Bengal Iron Co., Kulti	3,913
Bengal Chemical and Pharmaceutical Works, Calcutta	12,465
Dr. Bose's Laboratory, Calcutta	1,947
The Indian Iron & Steel Co., Burnpur	11,745
Bihar and Orissa—	
Tata Iron & Steel Co., Jamshedpur	34,689
Burrakur Coal Co., Loyabad	4,100
East Indian Railway Colliery, Giridih	1,045
Bararee Coke Co., Ltd., Jamadoba	4,198
Jharia Sulphuric Acid Co., Lodna	5,152
Tinplate Co. of India, Ltd.	6,627
Burma—	
Burmah Oil Co., Ltd., Rangoon	27,455
Bombay—	
Eastern Chemical Co.	11,591
Dharamsi Morarji & Co.	5,253
Madras—	
Cordite Factory, Nilgiri Hills	1,502
Parry & Co.	3,082
Punjab—	
Several small producers	2,563
United Provinces—	
Cawnpore Chemical Works, Ltd.	9,382
Other producers	856

This wide distribution of sulphuric acid manufacturing plants throughout India is a healthy sign of growing activity in chemical industries in the country, though, as might be expected, the objects of manufacture are very varied. Thus all the producers in Bihar and Orissa, and the Bengal Iron Company in Bengal, manufacture acid for their own ammonia by-product recovery plants; the Burmah Oil Co., Ltd. manufacture chiefly for the refining of petroleum products in the Burmese oil industry; and the Nilgiri Cordite Factory produces for the manufacture of explosives. All the other producers may be taken as manufacturing for general chemical purposes.

Production of ammonium sulphate.

The statistics of production of ammonium sulphate are given in Table 159, from which it will be seen that India produced 65,190 tons during the quinquennium, against 78,593 tons during the previous period.

TABLE 159.—*Production of Sulphate of Ammonia in India during the years 1929 to 1933.*

——	1929	1930	1931	1932	1933	Total
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Bengal	6,930	6,028	3,005	2,271	2,172	20,406
Bihar and Orissa	10,637	10,103	9,128	7,203	7,713	44,784
TOTAL	**17,567**	**16,131**	**12,133**	**9,474**	**9,885**	**65,190**

Producers of ammonium sulphate.

The principal producers were as follows, the figures being the total production during the quinquennium :—

	Tons.
Bengal—	
The Bengal Iron Co., Ltd.	5,362
The Indian Iron & Steel Co., Ltd.	14,336
The Oriental Gas Co., Ltd.	708
Bihar and Orissa—	
The Tata Iron & Steel Co., Ltd.	28,824
The Bararee Coke Co., Ltd.	5,638
The Burrakur Coal Co., Ltd.	5,647
Lodna Colliery Co. (1920), Ltd.	1,901
East Indian Railway Colliery, Giridih	1,583
The Eastern Coal Co., Ltd.	1,191

Ammonium sulphate is, of course, a valuable fertiliser for certain crops. During the quinquennium 1919-1923 the larger proportion of the Indian production was exported, mainly to Ceylon and Java, but exports during the five years 1924-1928, amounted to less than a third of the total output; the countries which received the greater portion of the exports between 1924 and 1928, were Ceylon, Japan, Spain and Java. During the quinquennium under review, the exports were less than an eighth of the production, and went entirely to Ceylon.

Exports of ammonium sulphate.

TABLE 160.—*Exports of Ammonium Sulphate from India during the years 1929 to 1933.*

Year.	Quantity in tons.
1929	..
1930	4,850
1931	3,051
1932	303
1933	1,313
TOTAL	9,517
Annual average	*2,379*

These exports are much exceeded by large and increasing imports totalling 126,271 tons for the quinquennium. These supplies were supplemented by imports of calcium cyanamide (including nitrolim), separate figures for which are, however, not available. For figures of imports of sodium nitrate see page 443.

Imports of nitrogenous salts.

Reference may also be made here to the recorded imports of ammonia and salts thereof summarised in Table 157, giving an annual average of 1,767 tons, against 1,353 tons for the previous five years, and utilised for general industrial purposes.

Sulphates of iron and copper.

For many years the pyritous deposits in India have been turned to account for the manufacture of soluble sulphates of iron and copper. The case of alum has been referred to already (*supra*, page 339), and with the alum, which was formerly obtained in quantity from the decomposed pyritous shales at Khetri and Singhana in Rajputana, copperas and blue vitriol were also obtained. No statistics are, however, available with regard to the history of these industries, which have had to give way to the importation of cheap chemicals from Europe, the imports of alum and copperas being considerable

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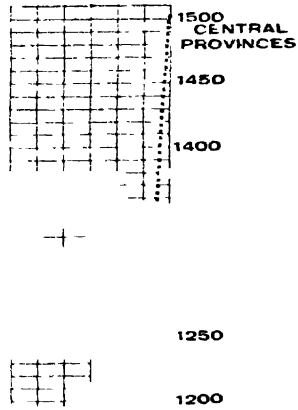
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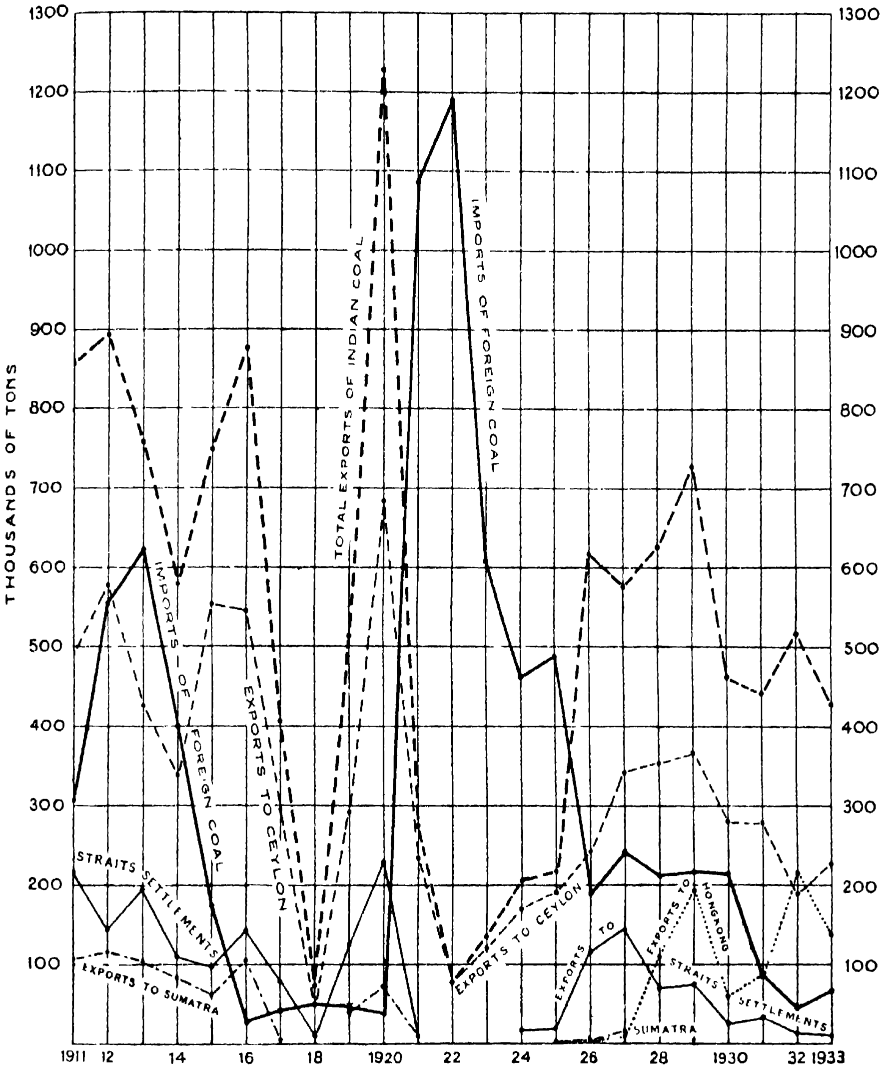

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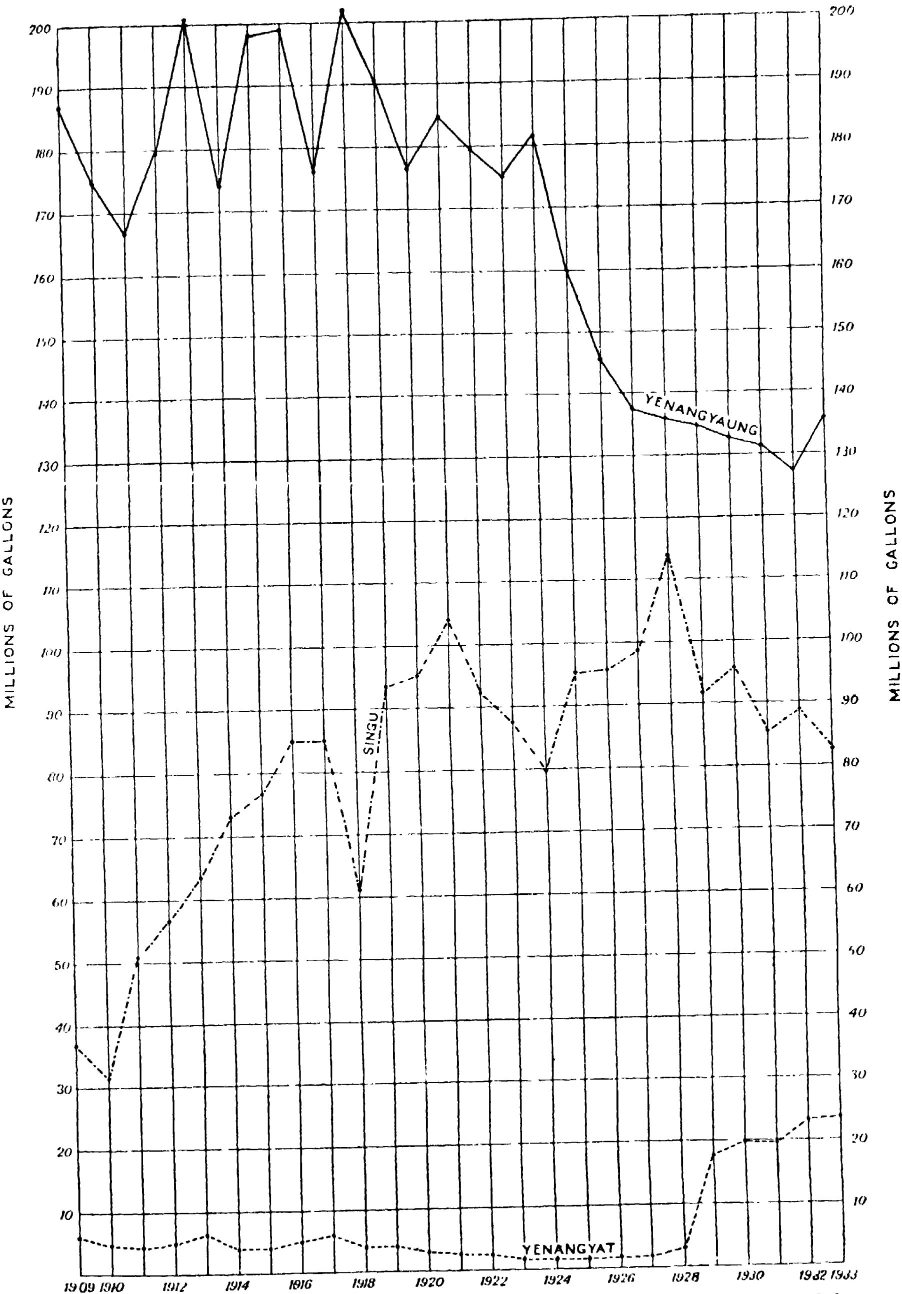
IMPORTS OF FOREIGN AND EXPORTS OF INDIAN COAL DURING THE PERIOD 1911—1933.



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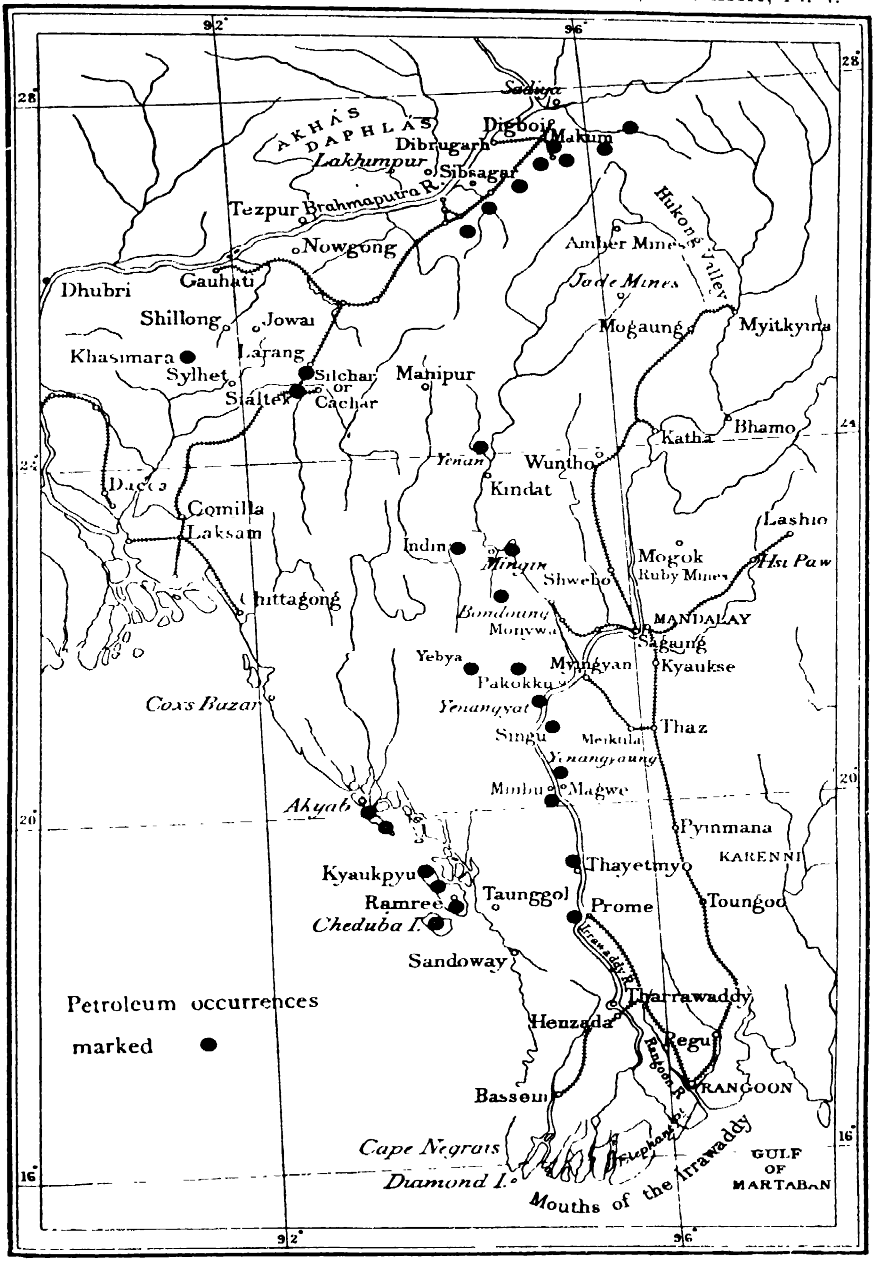

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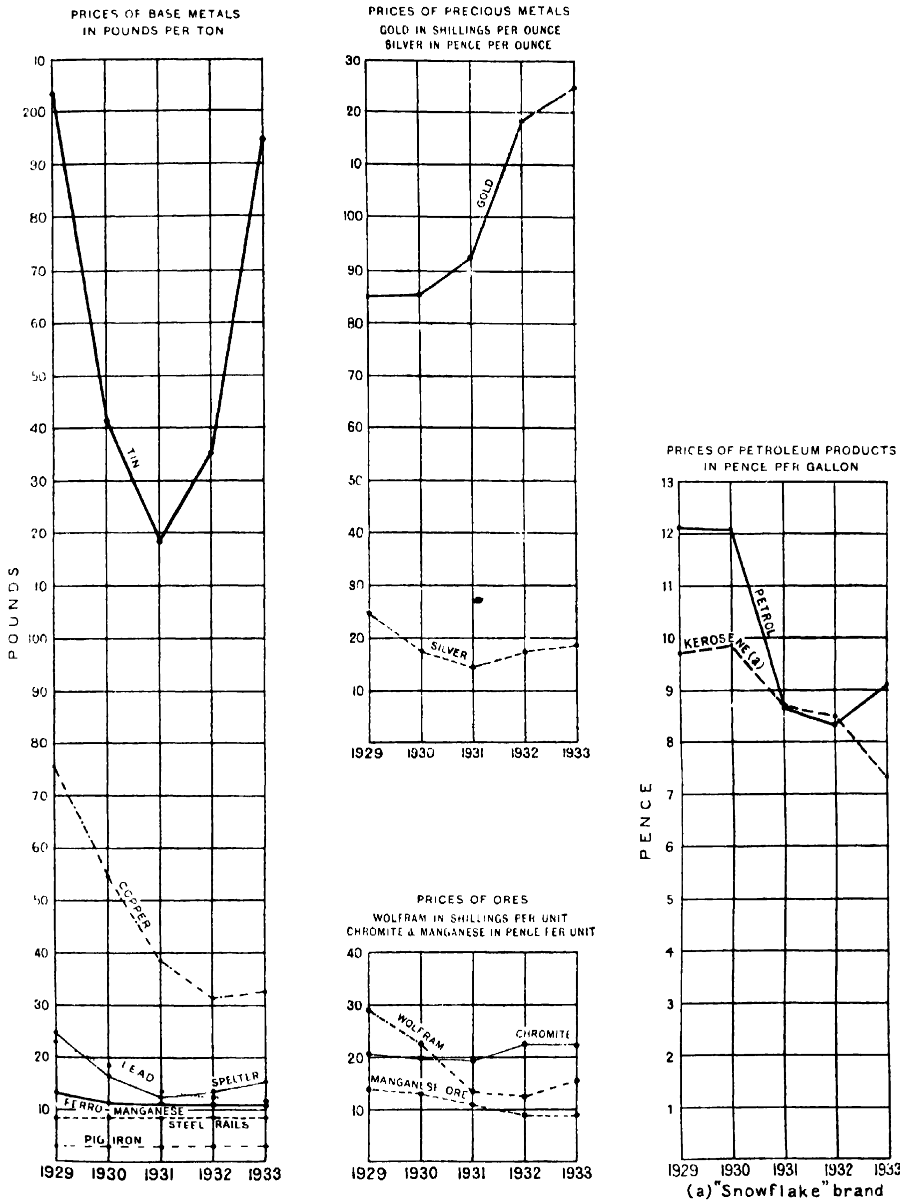
OCCURRENCES OF PETROLEUM IN ASSAM AND BURMA.

(Scale, 1 inch = 128 miles.)



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